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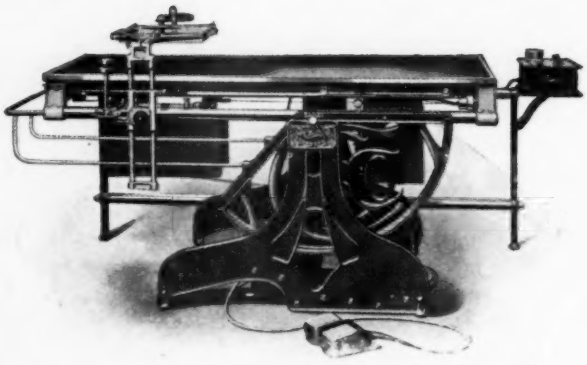

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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THE RELATION OF ROENTGENOLOGY TO CLINICAL MEDICINE WITH SPECIAL REFERENCE TO GASTRO-ENTEROLOGY*

By R. WALTER MILLS, M.D.

ST. LOUIS, MISSOURI

IT is my appreciated privilege to address you, and in accepting the invitation I welcome the occasion to discuss through your suggestion a subject that must have been with you, as with me, a matter of reflection. The subject was welcome too, because had it not been suggested I should hardly have had the temerity to air certain more or less intangible views heretofore painfully suppressed; for primarily I am not of your cloth, and have felt that possible heresies might not find favor among the roentgenologically elect. My regrets and plea for indulgence should this prove the case! It may happily be, however, that our views as professed roentgenologist or clinician become convergent in the end to mutual ground through respect for truth, service, the advancement of our beloved profession —and ourselves. But lest it be feared that I have violent Bolshevistic medical propaganda to scatter, let the worst be confessed at once, that my address pertains to a consideration of certain relationships and methods of utilizing roentgenology in clinical medicine, of the difficulty of advancing along present lines, and the possibility of more effective use of the *x*-ray through limitation in certain branches of roentgenology in a closer relationship to clinical medicine. As it is impossible to consider such a proposition in all branches, gastro-intestinal work may serve as an illustration, since it is peculiarly a problem demanding consideration along the lines indicated, though it does seem that other divisions of roentgenology are open to much the same sort of interrogation. Once again let me ask your charity. I shall be quite frank. Either we must discuss the subject or let it carefully alone. If any position taken seems at all radical let me plead the sincerity of my views and interest.

There is no precedent in any specialty for such a revolutionary factor suddenly developing as the *x*-ray has proven to be in gastro-enterology. Successful abdominal diagnosis prior to its advent was devious and largely a matter of shrewd guesswork. It has been transformed by roentgenology as practiced by skilled men into one of the most accurate subjects in clinical medicine. The influence of the *x*-ray on subjects collateral to gastro-enterology, surgery, topographical anatomy and alimentary physiology, is very great—only relatively less important. It has no limitations. The limitations are our own.

Read by invitation at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., September 14-17, 1920

Its only weakness is in its strength, in that it displays a living pathology so bewildering that we are as yet unable to arrange much of the evidence to fit present conceptions. It is conventional to assume a pose of conservatism on the value of the *x*-ray in gastro-intestinal work, but I have little doubt that the foregoing is about what with good reason we really believe, and it certainly seems the position of thinking clinicians to-day.

No one can hazard what the future of roentgenology will be, nor is it possible to imagine its accomplishments in the centuries to come; but there is every indication that it will continue to be highly revolutionary and very wonderful. We must recall that roentgenology is in no way limited to clinical medicine. There are even now indications of its future extensive utility in anatomy—topographical, osseous and organological, and in embryology. It will revolutionize certain conceptions of physiology, especially of alimentary motility and the relations to such of secretory function. It will be of help in pharmacology in observing reactions to drugs. It will have a great field in pathology in the location and determination of the extent of disease and in the study of abnormal densities as a reflection of the morbid processes in organs. There are many other opportunities for roentgenology having only collateral interest with clinical medicine, as in the fields of anthropology, biology generally, botany, geology, metallurgy and other purely scientific branches, not to mention its use in the arts and commerce. It is fitting that we take stock of the present in an effort to further the future.

It is a curious fact that what was accepted as knowledge yesterday often prevents the acquisition of subsequent truth. We resent any change in our laboriously accumulated information and ideas that may leave us without a comfortable base. We cling, concede and modify, and while it is no doubt well in some ways that this is so, since each new idea and contention must survive by beating down this inertia through sheer weight of truth, it is unfortunate that many fundamental facts are deflected or delayed in recognition by preconceived notions. A similar condition obtains with regard to our medical economics. We build our methods of practice by reconstructing previous methods of practice and ways of procedure, unmindful that times and conditions are changed and that more direct though radical ways may better serve.

Medical specialties are practically but a thing of the last generation. Ophthalmology was obvious, laryngology hardly less so; dermatology, neurology and the others followed fast; surgery, more slowly accouchée, labors still to some extent under the tender care of the practitioner who, from the advances of the chest and cardiovascular men above, the gastro-enterologist within, and the proctologist below, feels himself being rapidly restricted to diseases of the umbilicus. In such an age of specialization and dismemberment of medical practice suddenly appeared an unprecedented and powerful means of physical examination—unprecedented in its ways of operation touching every other specialty and allied medical science not casually but intimately, fundamentally, and often uncomfortably. Not abstractly as did laboratory work when generally introduced, but prying into clinical intimacies and faiths with ruthlessness. It was obvious from the first that roentgenology must become a specialty. We already had specialties in everything else. This was a simple enough business in the pioneer days when it was a question of finding someone to run the machine, and then but a matter of bones and bullets. I run ahead of my story by saying that the general practice of roentgenology has become in its intellectual requirements the most demanding and in its practice the most difficult of all specialties; the only one that to its full development requires a considerable knowledge of some of the most difficult phases of practically all other specialties and in addition embodies a technique which constitutes an art in itself.

The future of general roentgenology has even been held dubious on this account. Most

of us recall Dr. Hulse's address before this body several years ago, in which he suggested that the shadow of the dissolution of general roentgenology and its apportionment among the various specialties was upon us. However there is no present indication of such an untimely occurrence. Roentgenology waxes constantly more powerful and far-reaching, though one must admit that this seems at least due as much to its inherent strength as to our ability to harness it.

There are three ways of employing the *x*-ray in the practice of clinical medicine. Roentgenology may be practiced as a general consulting specialty as at present. It may be utilized by the clinician himself in his own branch. Roentgenology may be divided into subspecialties, each having as its field one or a limited and associated few of the major clinical specialties. I should like to speak of the second possibility first, the clinician as his own roentgenologist, theoretically the ideal arrangement, though as a matter of fact still awaiting a conclusive demonstration of its general possibility.

The technique of roentgenology is difficult and requires years to full accomplishment. Some time ago we heard much of reducing plate technique to formulae by which any novice could consistently reproduce the best results of the old masters. Such an idea omits several imponderables—to illustrate, the penetrability of the individual patient, the considerable matter of pose embodying a nice judgment of regional anatomy and statics, and the psychological control of the patient. One need hardly mention the time consumed in developing roentgenoscopic skill and the difficulty of maintaining a multiple factored technique in highest efficiency. The clinician has not the time to devote to the technical end, nor has he the knowledge to oversee and control a purely technical worker. He is fully occupied with affairs of his own, in keeping informed in his own line, and by the thousand time-consuming details, interviews, consultations and questions of management unavoidably associated with the treatment of patients. Above all he has not training nor time to acquire training in the interpretation of plate or roentgenoscopic shadows; he lacks the ability of the one constantly devoting himself to the art and deriving help from other problems. Again, few internists have a practice large enough to afford a material sufficient to acquire an affective knowledge of the roentgenological side. To become proficient one must see a large number of cases; must soak in his subject, become sensitized to it, constantly accumulating additions to his repertoire. There is a story told of Osler's quizzing a student as to how he came to recognize a certain patient as having paralysis agitans. The student guessed he knew it by the gait, by the tremor and the pill-rolling motion. "No," answered the professor; "Seen it before." Proficiency is not to be expected in any art without practice. The clinician may acquire a fair knowledge of the roentgenology of his subject, he may even find it so valuable and illuminative as to cause him to feel that the time devoted to it has been well spent; but for him to exhaust the possibilities, to squeeze from the method the last per cent of efficiency without limiting his purely clinical activities, seems hardly possible.

At that the clinician has something in his favor. His clinical knowledge will save him so that if he get but moderate assistance from his *x*-ray he can use it as a valuable check; at least he will be saved those frightful debauches of error met with in the ministrations of the inexperienced *x*-ray worker. Candor forces me to say that if he be a skilled gastro-enterologist and have but indifferent *x*-ray help available he may be better off doing his own work, as he can then be at liberty to accentuate his clinical findings; which he cannot so well do on the other hand if he have a formal opinion from an *x*-ray adviser which he takes considerable responsibility in overruling.

The clinician may acquire a knowledge of roentgenology, though at an impracticable loss of time. He may devote sufficient time to hospital work to gain proficiency, or he

may associate himself with others doing gastro-intestinal work, devoting himself to the *x*-ray end. In all these instances he becomes in large measure a roentgenologist whether he aspire to the honor or not. Certainly by so doing he limits his clinical capacity, though the arrangement may be highly effective and satisfactory; for the roentgenologist may develop from the clinical side.

One thing is sure; if the clinician attempts *x*-ray work at all he should develop it to a respectable degree. Doing some half-hearted fluoroscopic stunt under the guise of an *x*-ray examination is unfair if not dishonest to the patient, and a raw injustice to the men who have developed the subject often at bitter cost to themselves. Another phase of the situation is seen in internists accompanying their patients to the roentgenologist's, insisting on possessing the plates and so on. It is doubtful whether the clinician derives anything other than a mildly instructive value from such practice, and there is some question as to whether he is not wasting his time, for it hardly seems possible that he can learn enough in this fashion to make it worth while. It is doubtful too whether the roentgenologist is altogether happy in the arrangement. A different relationship between clinical and roentgenological sides is seen in the use of the *x*-ray by master specialists in their own lines when the roentgenological problems are sharply limited. Genito-urinary work, neurological surgery, and the problems of the rhinologist are instances in point. Certain men in these fields develop a highly specialized roentgenological service which they use with great effectiveness, this because they naturally cannot command help commensurate with their own knowledge in the general specialty. Even here they labor under the difficulty of lack of fundamental knowledge of roentgenology. However, some truly great advances have been made in this way, as frequently occurs where intensified combinations of various specialties are brought in contact.

All these efforts at adjustment reflect the fact that there is certainly an increasing tendency for clinicians to assign a position of greater importance to roentgenology, perhaps a secondary reaction after the first violent efforts at reconciliation and adaptation on the basis of the sometimes over-enthusiastic claims of the roentgenologists and prejudiced antagonism of clinicians. There is also indicated a desire on the part of clinicians generally to bring *x*-ray work in all lines into more immediate association. Though to repeat, one cannot but feel for reasons mentioned that such arrangements are destined to give the highest degree of satisfaction. The clinician is in a way rehearsing the development of the art; he has not yet encountered the obstacles. At the last meeting of the American Gastro-Enterological Association, forty per cent of papers were on, or discussed inclusively *x*-ray subjects. These papers were by orthodox roentgenologists, by clinicians and roentgenologists conjointly, by clinicians doing their own *x*-ray work, by clinicians whose *x*-ray work was done by others under their supervision, and by certain men doing intensive *x*-ray work or work utilizing the *x*-ray. The banquet address was by Dr. George on a purely *x*-ray subject. To repeat, it is impossible to explain this drift otherwise than that it represents effort at adjustment.

The second possibility as to the employment of roentgenology is as a general consulting specialty, the chief present arrangement. Its chief disadvantage has been foreshadowed in mention of the extent of the requirements of such a specialty. May it be but mentioned that it implies knowledge of all technical advances and refinements of technique, a knowledge of plastic roentgenography of the abdomen, of gall-bladder work and pneumo-roentgenology, of pylography, of cardiac mensuration, and of roentgen therapy now augmented by a new world in radium therapy. General roentgenology implies an extensive knowledge of gross pathology, a knowledge of alimentary physiology pertaining to motility, of the thousand exceptions and chameleon-like visceral changes resulting from bodily type, malstatic condi-

tions, variability in muscular development and tonus, and sensibility to pressure stimulation. It requires a familiarity with pathological statistics, operative surgery, of an unwritten topographical anatomy, orthopedics and surgical neurological diagnosis. It implies a knowledge of cranial osteology and of the variations encountered, especially of the sinuses—a life work in itself. A score of other equally difficult and various requirements come to mind. Recall, too, that in all these subjects the roentgenologist must often meet highly intensified clinicians with years of experience and accumulated judgment. Yet there are master roentgenologists whom we may indeed honor for the fullness of their accomplishments. Let it be recalled, however, that they have had the advantage of evolution with the specialty. Only the pioneer builds most soundly and fully. Can the succeeding generations successfully follow in their steps, confronted with the subject in its present form discouragingly vast and arithmetically progressive in its scope and requirements. It is difficult to believe.

There always will be a great field for the general specialty. Perhaps the majority of those following roentgenology in the future as in the past will be general men. There must be heads of hospital and group departments. In many places there is insufficient material and demand for subspecialization; the situation parallels the relationship of the general internist to the gastro-enterologist or the specialist in heart or pulmonary affections. But as in these fields it may be questioned whether best progress or superlative results are obtainable along general lines. There is a reflection of this in the fact that the leaders of your profession have made its progress by accentuating certain lines of work with which their names are associated. On the other hand, there can be nothing but advantage in a broad general knowledge of the subject by those who may ultimately restrict themselves.

A disadvantage of general roentgenology as usually practiced is that the roentgenological consultant is without or is largely deprived of clinical information—he is supposed to give his opinion on *x*-ray evidence alone with the idea that it will then be uncolored by any clinical facts. He may have no or but little directional access to history or physical findings. Should he for instance momentarily palpate a previously undetected abdominal tumor not giving *x*-ray evidence he might be hard put to it for a way to contribute his fact. Frequently most valuable information may be elicited during the course of a roentgenological examination. The most favorable opportunities for questioning and physically examining the patient arise at such time. They are taboo for the strict roentgenological consultant. He is supposed to do a complete or partial examination at the direction of the clinician. There seems a fearful lot of lost motion and lack of economy in such an arrangement. Theoretically every case must be plated to the last degree for all possible conditions, whether there be indication of their presence or not. What of the play of probabilities in such an arrangement? There are no positive facts in medicine—only varying probabilities. Much *x*-ray evidence amounts to probability or possibility only; yet it has its definite value none the less. The one time discussion of the advisability of mentioning suspicious gallstone shadows, always a moot question whose validity is expressed by its constant recurrence, is an illustration in point. All gallstone and gall-bladder shadows form a gradient between highly positive evidence and evidence that is indecisive. Has the latter no value? It may help to indicate the source of a serious focal infection and be of greatest worth taken in conjunction with clinical evidence of like inference. The same for cancer of the stomach, duodenal ulcer, and many other conditions. Are we justified in ignoring this fact in order to conform to our ritual? The idea is of course to restrict the roentgenologist that he may in no way be influenced or contaminated by clinical considerations, and incidentally that the clinician may have a comfortable yes-and-no basis on which to stand. It is difficult

to be satisfied with such an arrangement. Unless roentgenology is to be limited by rules like fly-fishing or fox-hunting, to be done in a certain way to the prejudice of results, we must have broader outlets. As a matter of fact many roentgenologists subscribe to this protest by obtaining, as they should have a right to, such directional evidence as can be collected in one way or another. The whole situation does not make for results or amity.

There are other less easily referred to sources of irritation. In a way the gastroenterologist feels that any method of examination in his field should be under his own jurisdiction. We must admit that it is not soothing that he must refer his patients to another for the most informative and important examination, and that the patient usually has a pretty good idea of the situation. The clinician cannot, from lack of experience, appreciate the difficulties of the roentgenologist's interpretations, but judges that his specialty is founded on a species of technical knowledge not open to himself. The clinician too has suffered at the hands of incompetents who lack knowledge and do not always seem to feel obliged to conform to the ethics of the profession. For all styled roentgenologists are not as we are; there are many publicans and sinners in the form of ill-trained men, commercial *x*-ray photographers, interns, sisters, and especially the technician of the small hospital taking great pride in its *x*-ray department founded by a wealthy benefactor. From these the clinician does not always escape. The very vastness and nature of general roentgenology makes it possible for such offenders to trouble where it would not be possible were the field divided among roentgenological experts whose profession and reputation implied an exhaustive special knowledge of their subjects and unimpeachable ethical standing.

There remains a third possible manner of utilizing roentgenology in clinical medicine; through an intensified subspecialization most effectively in association with clinical findings. It is realized that this is not the conventional method that has been developed, perhaps without a definite objective and along the lines of least resistance, yet which many careful men believe to be the most favorable arrangement possible at present. It can only be an advantage however to consider the situation from all sides.

There is no question of the extent of the opportunity for the truly expert roentgenologist in any line. It does seem that attempting to occupy too great a field by either roentgenologist or clinician is not conducive to exhaustive knowledge and best results. Why may we not have limited consulting roentgenological fields within the general specialty in the same way that we have subspecialization in certain medical and many non-medical lines; consulting engineers of a dozen sorts, specialization in a thousand forms in the business world. Medicine has always been slow in profiting by examples outside of the profession. The ghost of the old practitioner is still over us.

Such limitation would have multifold advantages. There is no question but that its members would be much appreciated by the various clinical groups. There can be nothing narrowing in such limitation. Who could say that limitation in other lines is not highly satisfactory when the field is large enough, of which there can be no question in roentgenology. Men like Harvey Cushing and Chevalier Jackson, essentially subspecialists, are indeed of the broadest type. The arrangement would certainly be a source of satisfaction to its practitioners, who would not feel that their efforts were being dissipated over too large a field.

I may anticipate your possibly not approving query as to what is meant by closer relationship to clinical medicine, for it is realized that this is the crux of the proposition. Ideally it would imply first a knowledge of the clinical aspects of the subject, especially the diagnostic side obtained if possible by actual service; a knowledge of the pathology, pathological statistics and literature of the branch; full familiarity with the matter

of history-taking and interpretation, and skill in physical examination when such may be of help in roentgenological interpretation, as in abdominal palpation. It should embody a familiarity with the surgery of the subject. An almost unattached field of opportunity lies in the possibilities which roentgenology affords for aiding in the problems of abdominal operative surgery. Recall that such a roentgenologist would see more of the judicial problems of surgery than many surgeons, having access to a larger and selected material. I can not but feel that history and laboratory findings should be available before the roentgenological examination is begun. What other sort of medical consultation implies that one of the consultants be deprived of all available information and left to work out his fate on his own resources?

There is one question with regard to the method advocated which is most essential and on which its feasibility rests—the question as to whether the roentgenological opinion would not be colored with clinical evidence. This need in no way be the case, but the roentgenological consultant must be meticulously honest with himself and his consultant. It is impossible to believe that because the roentgenologist had knowledge of clinical findings suggesting a localized pulmonary tuberculosis, that this would lead him to read more into his plates than was justified. Rather it would stimulate him to redouble his efforts; or having a doubtful finding it would add to the clinician's presumption. The method proposed represents in essence an effort to realize on clinical knowledge for more effective interpretation of roentgenological evidence; to conserve and emphasize the factor of probabilities, and to obtain the benefit of directional clinical indications in conducting the *x*-ray examination; to convey to the consulting clinician collateral evidence incidentally encountered, and especially to convey the real diagnostic weight of the *x*-ray evidence which he cannot so closely appreciate otherwise. Such a relationship would furnish too a common meeting ground for consultation in place of a one-sided submission of certain findings on a certain kind of examination now largely in vogue. It is the universal practice of men to reach important decisions only after personal debate, and there are obvious reasons for this custom.

We recognize the value of correlating clinical and roentgenological findings by certain of our present practices. The roentgenologist identifies a certain abdominal tenderness as registering with the appendix or a gastric ulcer crater. He identifies a palpable mass as corresponding to a defective visceral outline, this with diagnostic helpfulness; yet he is making concessions in so doing, for clinical findings are being utilized. May I attempt to illustrate the value of the method suggested. The possible outline of a slightly enlarged gall-bladder may be suggested in plates. The roentgenologist for one fleeting moment palpated a mass corresponding in position, size and contour to the doubtful plate shadow. The clinician did not happen to make his examination at a time when this was possible. Two doubtful findings pointing to the same conclusion here result in a strong probability. What is the alternative for the roentgenologist? He may either mention the suspicious gall-bladder shadow and in principle be condemned for not furnishing a definite opinion, or he may consider it not safe and sane evidence, ignore it, and be condemned again for the ineffectiveness of his method. He may consider abdominal palpation not in his line, and the patient will foot the bill of disaster. Other instances may illustrate. The illustrations are actual occurrences; many similar situations are within the experience of any of you. In a man of broad powerful physique a retrocecal appendix is made visible only on certain manipulations of the overlying cecum. When so made apparent and manipulated in a certain way it is found to be questionably tender, but only on such manipulation. The appendix is not structurally suggestive. There is a history of an attack of pain in the right upper abdomen

somewhat suggestion gallstone colic. There is no roentgenological evidence of gall-bladder disease. The clinician suspects gall-bladder disease. He has obtained no local tenderness as was elicited by the roentgenologist through the help of the maneuver mentioned. The roentgenologist, if highly orthodox, will report simply a retrocecal appendix not necessarily significant of a pathology. If a trifle less orthodox he might state that a somewhat tender retrocecal appendix was present. The roentgenologist knows nothing of the previous attack of right upper quadrant pain. The clinician will hardly be drawn away from his gall-bladder idea by the report of a retrocecal appendix, even if slightly tender; the appendix is as a rule tender where there is a neighboring inflammation. The clinician knows nothing of the high cecum resulting in the appendix approximating the gall-bladder region—the roentgenologist has no occasion to mention it. If however our consulting roentgenoligist had full access to clinical findings the parts of the puzzle would at once click into place—a subacute appendicitis beginning with an attack of pain whose location approximated the gall-bladder region on account of the appendix being retrocecal and high, contributed to by the physical type of the patient. The clinician could not reach such an opinion from his own findings or on evidence of the usually approved type furnished by the roentgenologist. Another illustration: A patient gives a history of an attack indicating a previous right upper quadrant local peritonitis. Physical findings are negative. Plates show a constantly filled and constantly perfect cap with the possible exception of certain slight irregularities along its lower border not identical in different plates and absolutely as near a fifty-fifty proposition as between an organic condition and spasm is possible. What will be the roentgenologist's position if he knows nothing of the history which suggests on probabilities either a leaking duodenal ulcer or a pericholecystitis? Since his evidence is strictly indecisive the broad logical thing to do would be to ignore conservatively the slight suggestion of a pathology and report his findings negative. A duodenal ulcer giving such slight *x*-ray evidence is not usually so serious a matter. The clinician too would be led to believe that the condition did not result from ulcer, since he would rightly judge that an ulcer resulting in local peritonitis would probably give roentgenological evidence. His next probability would be gall-bladder disease with pericholecystitis, at once bringing up the question of operation. Certain gall-bladder pathologies are said to give histories simulating ulcer. But this possibility is a bad second. He has absolutely no clinical evidence of gall-bladder disease, and the roentgenologist's findings are entirely negative for such. The clinician is nowhere—he is worse off than if he had had no *x*-ray examination done, for originally he had an ulcer possibility through a moderately suggestive history. In this particular instance, however, the roentgenologist knew of the clinical history. He was consequently not satisfied with his own findings, especially his just questionable lower cap border, and asked to repeat his examination. One plate of the second series showed the only partially filled cap obtained with evidence of deformity and a small duodenal ulcer crater in the center of the cap area. The explanation of the apparently perfect cap was that the anterior duodenal wall was entirely uninvolved and ballooned out giving a practically perfect outline and concealing a posterior deformity. Such illustrations or others less striking are of daily occurrence in any considerable gastro-enterological service.

It may be questioned whether clinicians would welcome such relationship as that suggested. I cannot but feel, after many conversations with them, that such roentgenological consultation would be greatly appreciated, provided that all special and ethical qualifications were fully met. Certainly such relationships could be developed in hospital services and among groups. We have used the method in hospital and private practice for eight years with entire satisfaction. In

the case of hospital, clinical and private patients the history and laboratory findings and the clinician's impression as to possible diagnoses invariably accompany the patient at every examination, and frequently chiefs and residents come voluntarily or are sent word as the case merits personal discussion. The roentgenological consultant often suggests additional clinical examinations and as frequently states that roentgenological evidence is not definite and that clinical findings are best decisive.

You may take it as you will as to the opinion expressed. It has indeed not been easy to lay my personal convictions before you; but the facts confront us. It does not seem that the clinician will generally be superlative as his own roentgenologist. It does not seem that roentgenology under present arrangements is being quite as effectively utilized as it might be through limitation and intensive cultivation in association with clinical medicine. It does seem that in this direction may lie the future, the evolution of roentgenology—a state in which the roentgenologist will indeed be physician and consultant, a master and adviser. There can be no question that we have at our disposal the most powerful diagnostic weapon in medicine to-day, or any day; does it not behoove us to use it wisely in the interest of culture and service?

THE ANOMALOUS RELATION OF ROENTGENOLOGY TO MEDICAL PRACTICE*

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ROENTGENOLOGY, though firmly established as an art, has not won universal recognition as a specialty of medicine. Any man who confines himself to referred *x*-ray work will suffer daily humiliation in the knowledge that his work is not universally regarded as that of a specialist in medicine. This paper, in discussing some of the reasons for the failure to recognize roentgenology as a true specialty, will do so by attempting to answer four questions:

1. What is a medical specialty?
2. How does roentgenology fail to conform to the requirements of a medical specialty?
3. Is it possible for roentgenologists to win general recognition as specialists in medicine?
4. If so, by what means, in addition to those already employed by us?

First.—There are two classes of medical specialties.

(a) The true specialties are all cleavages from general medicine along purely anatomical lines. The American Medical Association recognizes the following specialties of this type: obstetrics, gynecology, orthopedics, proctology, ophthalmology, otology, laryngology, rhinology, urology, dermatology, pediatrics, neurology, psychiatry, internal medicine, tuberculosis. It is universally accepted that the specialists will become proficient in, and utilize, all remediable procedures applicable to their respective fields, whether the administration of drugs, use of physical and mechanical appliances or surgical operations. The ophthalmologist does not think of referring his cases requiring operation to a general surgeon, nor does the urologist refer his patient with a kidney stone to the surgical specialist. More usually the contrary procedure occurs. A very bitter and acrimonious discussion in a medical society over the ethics of a general surgeon's operating mastoid or tonsil cases is recalled,

*Read before the Pacific Section of THE AMERICAN ROENTGEN RAY SOCIETY, Catalina Island, California, June 17-19, 1920.

the claim being that the general surgeon should not enter the anatomical fields which have been marked out as specialties. The ophthalmologist, at least, has legal endorsement of such a contention, because one State Supreme Court assessed damages against a doctor in favor of a patient from whose eye he had removed a foreign body. Although the doctor was licensed to practice medicine and surgery, the court held that the patient should have been referred to the ophthalmologist. If we were legally recognized as specialists to this extent, such a decision would be in our favor; but in our present status the point of vital importance is that the anatomical specialists are universally recognized as entitled to employ any method of therapeutics or diagnosis. They have as much ethical and legal right to use the *x*-ray or radium as they have to employ cocaine or a knife.

(b) The specialties founded on proficiency in methods, instead of on anatomy, are those of anesthesia, bacteriology, pathology, public health, clinical pathology, roentgenology and surgery. Several of these are, at best, only quasi-specialties, without a fixed and recognized relation to medical practice. Our medical organizations still debate whether nurses should be received as accredited anesthetists, so that anesthesia certainly is not regarded as a medical specialty; bacteriology and pathology, like materia medica and chemistry, are teaching specialties, and can be practiced by non-medical individuals; public health, as a profession, does not require a medical degree; clinical pathology is an important part of medicine, but is not, by any means, recognized by organized medicine as a specialty. The only two remaining specialties of this group, roentgenology and surgery, can very properly be discussed together.

Second.—How far do roentgenology and surgery fail to conform to the requirements of medical specialties? The development of surgery as a specialized department of therapeutics, and the very similar development of roentgenology as a specialized method of diagnosis, and as an ultra-refinement of surgery, offers a very interesting field of study, which we have not space to elaborate. Surgical treatment began with Paré who would to-day be considered a quack, and for a long time was in the hands of non-medical individuals. After surgical methods had developed into importance, the art was appropriated by the medical profession and incorporated into their therapeutics. Note the significant fact that surgery, developed as a specialty outside of medicine, was assimilated in such a manner that it disappeared as a specialty, and has only reappeared as such after a tremendous struggle, which has not yet ended. Roentgenology parallels this evolution very closely. We can claim a more aristocratic origin, being indebted to the dignified science of physics, in contrast to the plebeian ancestors to which surgery must confess; and the applicability of roentgenology to medical practice was more quickly recognized, while its development as a medical method took place so rapidly that its non-medical origin is usually forgotten. Both surgery and roentgenology have become specialties under stress of circumstances, with a constant tendency to revert to the original conditions. Surgery became specialized when the applications of the art grew so numerous and when the knowledge and training necessary to maintain adeptness required so much that a doctor could not continue general practice and be a successful surgeon. The anatomical specialists have never yielded the right to operate their own surgical cases, and wherever a general practitioner is able to overcome the difficulties mentioned in a manner at all acceptable, he becomes his own surgeon. The first users of the *x*-rays were not specialists. When complicated machinery was developed, when the use of large numbers of temperamental gas tubes became necessary, when the scope of *x*-ray work began to demand detailed and time-consuming research work with the constant study of pathology by the entirely new method of shadow interpretation, the field of roentgenology was yielded to those who were willing

to work in it. Some communities accept the roentgenologist as a specialist; the American Medical Association allows us to classify ourselves as roentgenologists, but has never officially recognized the art as a medical specialty. We have gone one step farther than surgery, in that the anatomical specialties have yielded their fields to us. But that this concession on their part is regarded only as a loan of a talent to be developed by us and then returned, is witnessed by the alacrity with which the ophthalmologist, the dermatologist, the gynecologist, the internist, the surgeon, takes over the application of *x*-ray and radium the moment he can make such a move remunerative.

When we view the long struggle of surgery to establish itself as a specialty, we are convinced that this effort will succeed, at least so far as the general surgeon is concerned. But this recognition of a branch of therapeutics as a medical specialty will be won by sheer weight of numbers, and will need to be maintained by the Teutonic principle of "might makes right."

Third.—Is it possible for roentgenology to win from the general profession similar recognition as a specialty? It is certainly not to be expected that a new specialty, whose entire claim to recognition is based on proficiency in a new *method* of diagnosis or therapy, applicable to all the anatomical specialties, will be allowed to remain in our possession if it can be assimilated by the general medical body. If roentgenology and surgery succeed, they will represent the only successful attempts of many to establish specialties based on methods instead of anatomy. Hahnemann, the founder of a new method of therapeutics, was forced to start a new school of medicine in order to establish a specialty. The specialty of immunological therapeutics had a brief day and disappeared by absorption. Orthopedics, once based on the use of methods and appliances, had to be reorganized on an anatomical basis in order to prevent its total disintegration. Dietetics, hydrotherapy, electrotherapy, heliotherapy, can only flourish in the twilight zone of medicine, without any real standing as specialties.

Will roentgenology, from this day forward, gradually diminish in importance as a specialized form of medical practice, and eventually disappear as such? Or have we the inherent worth, sufficient numbers and staying powers, to capitalize our past achievements and duplicate the victory of surgery in establishing a medical specialty against precedent?

To these two questions no definite answer will be offered; but if you doubt the pertinence of such a discussion, I would say that this is an effort to crystallize the fears which have been expressed in every Roentgen Ray Society meeting I have attended for the last four years. Beginning with the oration of Dr. Hulst, in Chicago, in 1916, who said that our specialty was merely a preparatory one to develop methods which would be possible to every physician and surgeon, we have seen a gradually increasing drift toward the fulfillment of this prophecy. There is no need to elaborate instances, because all of you who practice in large cities know of specialists who are very proficient in the application of *x*-ray or radium to their limited fields. Let us not blind ourselves to the facts which are before us; remember that the world was nearly destroyed because of the inability of a great nation to see the plain facts which had been unfolding before its eyes for years. We cannot maintain our specialty even in its present unsatisfactory relation to medicine by resting on our past achievements. We must either disintegrate or develop our resources into something which has more *political* force and which cannot so easily be camouflaged.

Fourth.—How can we hold the field which we have won? Three factors have enabled us to develop our specialty to a high degree of efficiency; but efficiency has not, and will not, win us recognition from our medical brethren. If these three factors, or any two of them, can be overcome by the individual physician or surgeon, or group of such, the roentgenologist as a specialist will,

in all probability, be dispensed with by such individual or group. The three things which have worked in our favor, and still exert some influence, are (1) the machinery; (2) the pathological interpretation; (3) the time and cost of *x*-ray examinations or treatments. Just how permanent are these factors?

Simplification of machinery, apparatus and technique has been accomplished so rapidly that we have not been able to keep pace with it ourselves. With the self-rectifying tube and transformer of Coolidge, having the high tension discharge completely insulated by immersion in oil, it will not be unreasonable to expect diagnostic *x*-ray machines soon to be as common in doctors' offices as sphygmomanometers.

Roentgenologists must, of necessity, be highly specialized in disease pathology, with the additional ability to translate this knowledge from *x*-ray shadows into clinical terms. Just to the extent of this pathological knowledge and our ability so to translate it, depends our proficiency in our specialty, and we have a temporary protection in the monopoly which we have on such ability. But the masters of our art are teachers in medical schools throughout the land, and their eminent success is shown in their yearly product. The graduates of the past few years come into our laboratories and follow every move intelligently; they show an astonishing ability to interpret the pathology from the plates of their cases. They are a warning that the future generation of medical men can, if they choose, be independent of us. We must, therefore, constantly extend our field of work to keep pace with every advance in medicine, surgery and pathology. A close alliance between pathology and roentgenology is absolutely essential for our preservation.

The time element and cost element are, when all things are considered, still the most potent factors in the development of our specialty. The machinery has not yet become so simple that a doctor just starting practice can afford to operate his own *x*-ray laboratory, and the busier he becomes the less time will he have to devote to this time-consuming work. A surgeon cannot afford to spend an hour over a $25.00 *x*-ray examination, when he can be removing a $250.00 appendix which a consulting roentgenologist has definitely located where he can find it. However, both the time element and the interpretation of pathology are much less formidable barriers to the specialists with limited fields of work. While we are endeavoring to keep our art up with the general advances in medicine and surgery, we are very likely to find the specialists crowding us and demanding better results in their particular fields. If these results are not promptly forthcoming, they are very likely to undertake their own researches. This vulnerable point can only be protected by our giving better results, more quickly, and for less money than the specialists can secure for themselves.

In addition to closer attention to these factors, which have in the past permitted the development of our specialty, two other things are essential for our immediate protection and future development. These are efficient organization and universal propaganda. This paper has no space for elaboration of these very vital activities, and bare mention of them must suffice for now.

Roentgenologists are very indifferently organized at present. The society whose Western Section is here represented, although purporting to be the representative body of roentgenologists on this continent, contains fewer than twenty-five per cent of the accredited and qualified roentgenologists of the United States, and barely ten per cent of those west of the Mississippi. It would be unseemly in me to criticize our parent society, but it is proper to make the suggestion that we are in need of a more comprehensive organization, one with a fuller understanding of the needs of our specialty in its relation to general medicine. The man who enters this specialty in its present condition of undetermined status—legally at least—should have the backing of the most powerful organization, one not only supreme in its

scientific attainments, but one which can wield a potent political influence in the field of general medicine.

Such an influence is to be won by propaganda. Besides the failure to be sufficiently comprehensive in numbers, all of our roentgen ray societies deliberately plan and effectively maintain, a beautiful isolation from general medicine. It is small wonder that our professional parent will not own us as a legitimate child. Individual members of our specialty, realizing this fault, take their work before general medical and surgical bodies and secure individual recognition and reward, but our organizations are fearfully unresponsive to this crying need. As long as we can find fairly well-informed physicians telling patients that the *x*-ray is of no value except in fractures, as long as surgical societies will applaud the statement that radium never arrested a cervical cancer, as long as members of the American College of Surgeons will amputate the tongue for early cancer of that organ, as long as breasts are amputated in hospitals with *x*-ray departments, and the cancer allowed to recur without any thought of roentgen therapy, as long as patients are told (in candor) that exploratory surgery is the only way to diagnose gallstones, there is a need crying to high Heaven for our propaganda. To be effective, this should be directed by our organizations, should be persistent, should reach every county, state and national medical society, and should continue until there is universal recognition that our work requires medical men of the highest degree of specialism in disease pathology.

It is my personal belief that roentgenology, so far as the diagnostic use of *x*-ray is concerned, is due to be submerged in the larger field of clinical diagnosis. The practice of medicine at present rests on three cornerstones—diagnosis, medical treatment, surgical treatment. Clinical diagnosis is a specialty which is slowly evolving from several of the quasi-specialties previously mentioned—bacteriology, serology, pathology, clinical pathology, in conjunction with roentgenology, electrocardiography, etc. There is already more or less of a demand, which will increase with the complexities of medical practice, for a correlation of all methods of diagnosis into one specialty. It is entirely possible that such a field will be so large, especially in large cities, that it will need to be split into departments, of which roentgenology will be one. There are several excellent illustrations of roentgenologists engaged in such work. A notable one is that of a former president of THE AMERICAN ROENTGEN RAY SOCIETY, who practices the specialty of clinical diagnosis, utilizing *x*-ray interpretation simply as a part of his larger work.

Although such a development is largely a matter of the future, it is well worth considering whether our specialty will not find its ultimate and proper sphere by merging with other companion specialties to take possession of the coming field of clinical diagnosis.

THE ACTION OF BURIED TUBES OF RADIUM EMANATION UPON NORMAL AND NEOPLASTIC TISSUES

I. With Special Reference to the Therapeutic Dose in Experimental and Human Cancer.

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From the Huntington Fund for Cancer Research, Memorial Hospital, NEW YORK CITY

THIS investigation was undertaken to determine experimentally, by careful histological observation, the character of the changes produced in living tissues, both normal and neoplastic, by the radiations from very small glass tubes containing radium emanation buried in the tissues; and also to determine the area of effective radiation about the tubes.

This so-called "buried emanation" method had been in use at the Memorial Hospital for some time, when several questions arose concerning its use:

1. Is the effective area of radiation about the emanation tubes, i.e., the area in which the tumor cells were destined to undergo degenerative changes, the same for all practical therapeutic purposes for the tubes of 5 mc. strength (which was about the strongest tube used) as for tubes of half that strength, or even for a fraction of 1 mc.? This question is of considerable practical importance from the standpoint of determining the most economical and yet efficient use for the available radium.

2. Assuming the above question answered, and the practical dose determined, how far apart should the radium emanation tubes be placed to radiate efficiently a given mass of tumor tissue?

3. Do the various types of tissues exhibit about the same reaction to the same dose?

4. Do the clinical results show that properly distributed small doses of buried emanation produce the desired results with greater safety, and less pain and discomfort to the patient, than a comparatively large dose of radium per tube? And, in this connection, can tumor destruction be obtained without extensive sloughing?

EXPERIMENTAL METHODS

To answer these questions the problem was approached from three different angles: *First:* A large series of radium emanation tubes of different strengths, varying from 5.5 mc. to as low as 0.1 mc., were imbedded in normal rat tissues, in the muscles, subcutaneously in the testes, brain, and other parts of the body. *Second:* A series of rat tumors, the Flexner-Jobling rat carcinoma, was treated with radium tubes of different strengths. *Third:* With the cooperation of Dr. Harold Bailey, the conclusions obtained from the experimental work were tested upon several types of human cancer, from which cases careful clinical data gave an estimation of the practical value of the methods employed.

The tubes containing the radium emanation were cut from very fine glass capillary tubes.[1] They varied from 2.5 to 4 mm. in length, and were about 0.4 mm. in diameter, with containing walls about 0.1 mm. thick. The radium tubes were inserted in the tissues by means of a long steel trocar. The tubes were first placed near the sharply pointed end of the trocar, before it was discharged by pressure on the central plunger.

[1] The method of preparing the tubes has been described by Dr. William Duane in the *Boston Medical and Surgical Journal*, Dec. 1917. Mr. Gioacchino Failla, physicist to the Memorial Hospital, has recently constructed an apparatus for the uniform cutting of the radium emanation tubes.

The tubes and trocar are illustrated in Figure 1.[2]

In the experimental studies concerning the radium changes produced in normal animal tissues, the tubes were left in place from thirteen days to several months before the histological examinations were made. In treating the Flexner-Jobling rat carcinoma the tissues were killed and examined at intervals from twenty-four hours to several days after the insertion of the tubes.

The tubes were located in aniline oil preparation, and drawings of the cleared sections were made before the tubes were removed from the tissue.

As a control to the above experiments, tubes recovered from previously treated tissues, and which had lost their radio-activity, were again inserted by the same technique into other living tissues. Any degenerative changes due to the traumatism incident to the insertion of the tubes would then act as a check on the comparative severity of tissue reaction in response to tubes with and without radio-activity.

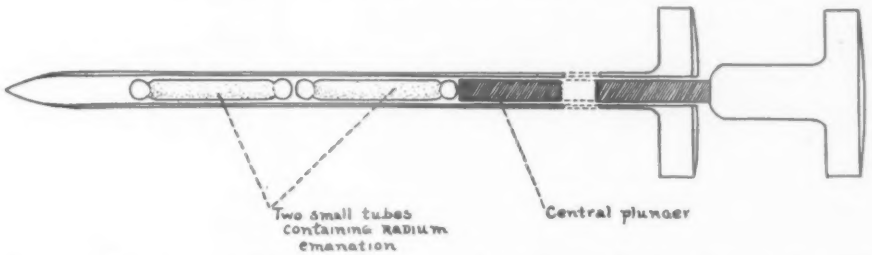

FIG. 1. SECTIONAL DIAGRAM OF TROCAR USED FOR THE INSERTION OF RADIUM TUBES. Two tubes are shown in position. Diameters x8.

EXPERIMENTAL RESULTS

SERIES A. *Buried Radium Emanation Tubes in Normal Rat Tissues.* Thirty-five tubes were inserted in a wide range of living tissues—skin muscle, brain, testes, on bone surfaces, etc. The strength of the tubes varied from 5.5 to 0.1 mc. each, and the tissues were examined in from thirteen to sixty days. As a result of the histological study of the radiated tissues it was found that: (1) The immediate area about the tube was necrotic, an elliptical solid in shape, and about 5 mm. in diameter; and this change was practically uniform for the different amounts of radium that were used. The physical conditions bearing on this case will be taken up later in the discussion of results. (2) Beyond this area of necrosis was an irregular zone of tissue, from 2 to 3 mm. more, showing definite radium changes; edema, hypochromatism and karyorrhexis of nuclei, capillary congestion and extravasation of blood, with lymphocytic infiltration. The total area of tissue showing marked radium degeneration was about 1 cm. in diameter. Beyond this area the radium changes were ill-defined, and much less pronounced.

Plates I to V show the radium changes that occur in skin, muscle, testes and brain tissue.

On September 25, 1918, a radium tube containing 1.4 mc. was placed beneath the skin of a well grown, healthy, adult white rat, and the tissues were examined at the end of seventeen days. The treated area was widely excised and immediately placed in fixative. The histological changes are shown in Plate I. Surrounding the tube, for an area of about 4 mm., was a zone of necrosis, with a central softening of the tissues in the immediate proximity of the tube, which re-

[2] In treating human cancer, when the lesion is of considerable depth and somewhat inaccessible, as in the case of carcinoma of the prostate, in order to avoid unnecessary traumatism it is found convenient to insert several tubes at one time in a single trocar. To do this the tubes must be selected with an outside diameter slightly smaller than the lumen of the trocar; otherwise the tubes may overlap at their ends and jam within the instrument. By careful manipulation of the plunger, the tubes may be inserted at different levels of the growth.

sulted in sloughing at that point. As shown in the illustration, the central excavated area is longer in one direction than in the other, but this is due merely to the size and shape of the tube itself. For the sake of clearness the exact position of the tube has been indicated in ink on the photograph. Beyond the area just mentioned there is an additional zone showing marked edema, some exudate, and less severe degeneration of the tissues extending over a total area of about 1 square centimeter. Over most of this region the epidermis is eroded, and covered with dry scale containing pus. The results show that, roughly speaking, the volume of degenerated tissue in the immediate vicinity of the radium tube was 1 cubic centimeter. From a therapeutic point of view this is one of the main results of the investigation, since this condition appears to hold good for tubes between about 1 to 5 mc. in strength.

Plate II shows complete necrosis of muscle tissue in a rat's leg about a much weaker radium tube, 0.4 mc. This was also left in place for seventeen days. The section was cut nearly perpendicular to the axis of the radium tube, and the hole from which the tube was taken is indicated in the lower left hand corner of the photograph. Only the radiated tissue on one side of the tube is included in the illustration. There was complete necrosis of muscle tissue over a zone 4 mm. in diameter, surrounded by an area of edema, degeneration of muscle fibers, and lymphocytic infiltration over an additional zone, about 2.5 mm. in width. The total area

PLATE I. REACTION FROM A SMALL TUBE OF RADIUM EMANATION, CONTAINING 1.4 MILLICURIES, LEFT UNDER THE SKIN OF A NORMAL RAT FOR 17 DAYS. There is a central area of necrosis,surrounded by a zone showing marked edema, and typical degeneration of tissues due to radiation. The area of destructive reaction is 1 cm. in diameter. the tube has been sketched in the photograph. Magnification, x14. (For further reference see text.)

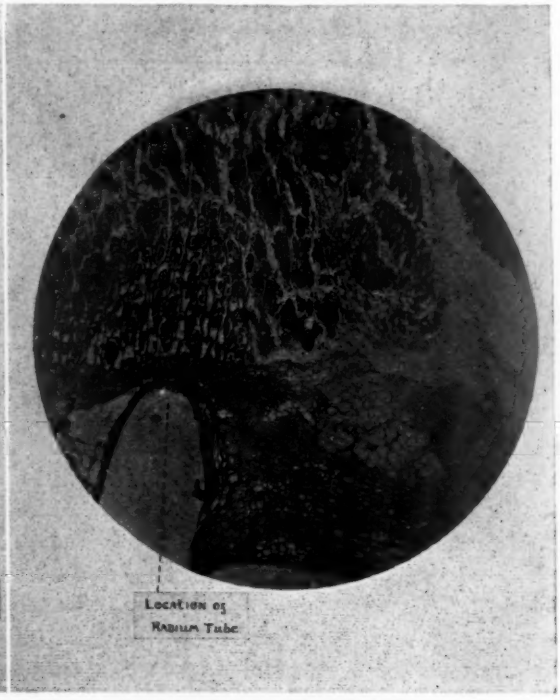

PLATE II. RADIUM REACTION FROM A GLASS TUBE CONTAINING 0.4 MILLICURIES, INSERTED IN THE LEG MUSCLE OF A RAT FOR 17 DAYS. The area of necrosis about the tube, plus an additional zone of degenerated muscle fibers, with lymphocytic infiltration, composed an area of definitely radiated tissue 9 mm. in diameter. The section was cut perpendicular to the axis of the radium tube. Magnification, x47. (For further reference see text.)

of radiated tissue in this case was about 9 mm. in diameter.

A still weaker radium tube, 0.2 mc., was placed in the center of a rat's testes and left there for twenty days. The histological picture is given in Plate III. The central area of necrosis was about 4 mm. in diameter. The peripheral portion of this zone showed hypochromatism and karyorrhexis of the nuclei of the seminiferous tubule cells. The surrounding zone, 1 to 2 mm. wide, showed edema, degeneration of tubule cells, and capillary congestion. The blood vessels of the entire testes were gorged with blood. In this case the total area of radiated tissue was about 8 mm. in diameter.

The histological material represented in Plates IV and V is not exactly comparable to the preceding sections, since the radium tube was separated from the tissues by the thickness of a rat's calvarium. The section is presented because it shows in a very striking manner the leukocytic infiltration which the tissues set up in an attempt to localize the irritant. The tube contained 1.2 mc. of radium emanation. It was placed under the scalp in the right cerebral region, and left there for 30 days. The scalp immediately above the tube was destroyed over an area of 8 by 10 mm. The brain lesion showed a central necrotic area, 4 by 5 mm. in diameter, which was sharply demarcated by a broad zone of polynuclear leukocytes, beyond which was a wide area of hyperemia and some pial-edema. The ganglian cells near the necrotic zone showed marked hydropic degeneration, and all the nuclei stained poorly. Some of the cells were completely broken up,

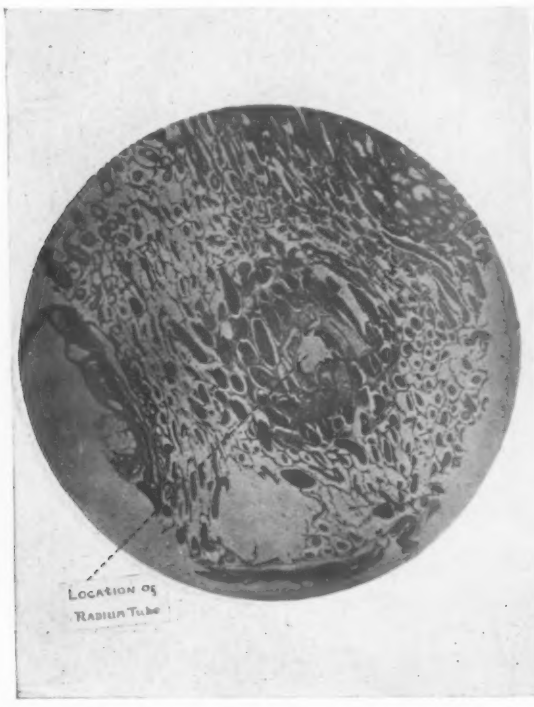

PLATE III. TESTES OF A *RAT*, showing radium changes about a glass tube containing 0.2 millicuries, left in place for 20 days. The central necrotic zone is surrounded by an area of radiated tissue showing hypochromatism and karyorrhexis of nuclei; degeneration of tubule cells, edema, and capillary congestion. The total area of radiated tissue in this case was 8 mm. in diameter. The section was cut perpendicular to the axis of the tube. Magnification x16. (For further reference see text.)

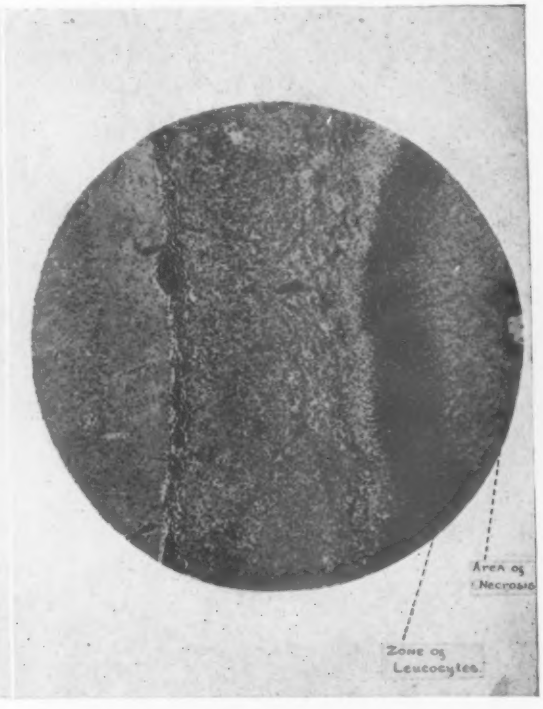

PLATE IV. HIGH POWER PHOTOGRAPH OF THE LEFT, MIDDLE REGION OF THE LESION SHOWN IN PLATE V, showing a portion of the area of necrosis at the right, the zone of leukocytes, and a wide area of hyperemia. Magnification, x60. (For further reference see text.)

there were minute blood extravasations with some increase in the small compact nuclei in this area, and the neighboring pia showed marked round-cell infiltration. The cells of the adjoining convolutions showed chromatic bodies that did not stain well. There were pericellular and perivascular edema. The cerebellum appeared normal, but the chromatic bodies and Purkinji cells did not stain well. Plate IV shows a high power view of the periphery of the lesion, which extends beyond the mid-line of the brain.

PLATE V. LOW POWER PHOTOGRAPH OF A NORMAL RAT'S BRAIN, selected to show the marked leukocytic infiltration, tending to localize the effects of the radiation. A glass tube containing 1.2 millicuries was placed between the calvarium and scalp, and left in place for 30 days. Magnification, x8.5. (For further reference see text.)

PLATE VI. This is a lesion produced by a single radium emanation tube, containing about 2 millicuries, inserted in a carcinoma of the prostate; showing a central area of complete necrosis, with much leukocytic exudate, beyond which there are definite radium changes.

SERIES B. *Buried Radium Emanation Tubes in Flexner-Jobling Rat Carcinoma.* Because of the rapidity with which the tumor cells respond to treatment, it was found more difficult to determine the area of radiated tissue about the radium tube in a growing tumor than in normal tissues. In some cases the tumor was promptly reduced in size, but again, attending inflammation and edema may be considerable, and although the actual amount of living tumor cells is reduced, the total bulk of tissue may appear increased.

To determine the radium changes that occur in the transplantable rat carcinoma, the technique of Series A was followed; 30 radium tubes were inserted in tumors of different sizes, and the tests were divided into three groups: (1) The tumors were treated four weeks after transplantation, and the animals were killed at the end of one, two, four and seven days respectively. (2) Tumors were treated with small doses of radium, evenly distributed throughout the growth, and placed as nearly as possible 1 cm. distance apart. (3) Radium tubes of the same strength were placed in tumors,

but unevenly distributed, some of the tubes being more than 1 cm. apart.

Although these experiments are still being pursued, the results so far obtained are interesting enough to warrant their being mentioned here.

In the first group of cases no definite histological changes were noted in the tumors until two days after the insertion of the tubes. At that time an area of necrosis, 2 mm. in diameter, surrounded the tube, while the changes beyond this zone were indistinct, save for considerable edema, about 1 mm. away in the tumor capsule. In the case of the tumors examined one day after treatment, the radium tubes were inserted a slight distance beyond the growing peripheral area of tumor tissue into the necrotic center of the mass. No radium changes were noted in the surrounding tumor cells. Tumors examined seven days after treatment showed definite radium changes, and it is to be noted that it takes several days before this definite effect may be expected. In one case the tumor nodule, when selected for treatment, was slightly over 1 cm. in diameter. One tube of 0.3 mc. was inserted in the center of the mass, and seven days later the central area surrounding the tube was completely necrotic, and irregular necrosis extended throughout the tumor mass. The outlying cells showed marked hypertrophy and hyperchromatism of the nuclei, and many cell bodies were very large and markedly hydropic. This case showed an effective area of radiation of at least 1 cm. in diameter which was similar to the reaction in normal tissues.

In the second group, tumors have apparently disappeared after treatment with evenly distributed small doses of radium. A history of one case will serve as an example. A tumor was transplanted to a healthy, well-grown male rat on November 20, 1919. On December 30, the resulting tumor was a mass 2 cm. in diameter. It was treated at that time with 3 tubes of 0.3 mc. each, placed 1 cm. apart, and about 5 mm. below the surface. On January 7, the tumor was slightly reduced in size, and a small amount of exudate appeared on the surface. On January 23, the tumor was further reduced to two-thirds of the original size, and a small sinus, extending to the necrotic center, appeared on the surface of the growth. Evidently a good deal of the tumor mass was being discharged on the surface. On February 10, the cure might be said to be complete; the animal was in good physical condition, the tumor had completely disappeared, and on removal of the local scar no tumor tissue was found in the locality, or in any other part of the body. The tumor used was highly malignant, and one which early in its history metastasizes to the neighboring lymph nodes, the lungs, etc. Other tumor nodules of about the same size have given similar results; but the destroyed tumor cells were generally absorbed with no surface sloughing.

The third group of cases, i.e., those that were treated with similar small doses of radium, some of the tubes being placed more than 1 cm. distance apart and unevenly distributed throughout the growth, gave results that showed the ineffectiveness of this method. The tumors were not sufficiently radiated to control their growth, local repressions were noted about the tubes, but the outlying tumor cells retained their atypical properties, and in all cases the tumor process eventually resulted in the death of the animals.

SERIES C. *Control groups. Non-Radio-Active Radium Emanation Tubes in Living Tissues.* Radium emanation tubes were recovered from previously treated tissue and again inserted in living material. In all cases they were found to be practically inert, while the tissues adjacent to the tube showed none of the degenerative changes so typical in living tissues after exposures to radium. There was no evidence of hyperchromatism, capillary congestion, edema, etc.

SERIES D. *Buried Radium Emanation Tubes in Human Cancer.* Following the general principles determined from the experiments presented above, several cases of car-

cinoma of the vulva have been treated at the Memorial Hospital by Dr. Harold Bailey.[3] These were fairly well localized lesions, and the histological diagnosis was made by Dr. James Ewing.

So far this method of treatment has been extensively applied only to carcinoma of the vulva, and no claim is made for the practibility of the similar use of radium for different kinds of cancer in other anatomical situations; but we know at least that vulva carcinoma is one of the most fatally malignant, rapidly recurring types of cancer that the clinician has to deal with, and the possible control of this neoplasm would be encouraging from other standpoints. Operative procedures have been discouraging, not only because of prompt local recurrence after excision, but because of the rapidity with which metastases, apparently traumatic in origin, follow the rich chain of lymphatics situated in this region.

About ten cases of primary carcinoma have been treated by the methods described in this article. The lesions were in the vulvovaginal region, and in one case there was an involvement of the external urethral orifice. The lesions varied in size, from masses 6 by 5 cm. in area and 1 cm. in depth, to much smaller masses (2 by 1 cm.), which were fairly superficial. They were all treated with small glass tubes containing less than 1 mc. of radium emanation, distributed as nearly as possible 1 cm. distance apart throughout the growth. Generally tubes varying from 0.2 to 0.5 each were used.[4]

The results so far obtained have been rather striking, in so far that in several cases, where the lesion has been treated with weak doses evenly distributed, complete regressions have resulted in the radiated areas, with practically no pain or discomfort to the patient, and with none of the disagreeable sloughing of tissues, which so promptly follows relatively severe reactions.

It has been found difficult to obtain satisfactory histological material showing localized changes in carcinoma of the vulva, although several attempts have been made to obtain small pieces of tissue for this purpose.

In order to show the similarity in effectiveness between radium changes in experimental and human carcinoma, the writer has selected the specimen shown in Plate VI. This specimen was taken from the series of pathological slides at the Memorial Hospital, which show localized effects from buried radium emanation.

Plate VI shows the area of radiation about an emanation tube, about 2 mc. in strength, in carcinoma of the prostate. In the dense fibrous tissue between the prostatic lobules is an area, about 5 mm. in diameter, of complete necrosis, associated with much leukocytic exudate. Over the entire section, about 1.5 cm. in length, all the tissues show a peculiar, hyaline degeneration, and stain poorly. The epithelial cells lining many of the tubules are enormously distended by hydrops. This specimen shows that the localized effect from buried radium emanation is practically the same for carcinoma of the prostate, and for emanation in experimental animal cancer, and normal animal tissues.

DISCUSSION OF RESULTS

So far as the writer has been able to ascertain, Dr. William Duane was the first scientist to appreciate the usefulness of burying unfiltered tubes of radium emanation in tumor tissue. He began his work on the problem in 1908 in Paris. In 1914, Joly and Stevenson reported their results from the use of similar methods in the *Proceedings of the Royal Dublin Society*, and the *British Medi-*

[3] At present only a general account will be given of the usefulness of these methods in human therapy. With the cooperation of Dr. Bailey, the clinical data are being collected, and will be published in the near future.

[4] The glass tubes and needles were sterilized by boiling. If the neoplasm is situated in the proximity of bone tissue there is always the possibility of inadvertently breaking the delicate glass tubes during their insertion, and thus liberating the emanation before it can be of therapeutic value; but the tubes alone we have found to be inert, and recent experiments of the writer have shown that the radium emanation is so strongly bactericidal that the inside of the tubes are also sterile.

cal Journal.[5] And also at about this time, Dr. H. H. Janeway began to employ the method of buried emanation at the Memorial Hospital, where at the present it is one of the standard methods of treatment for certain types of cancer.

Projecting from a tube containing radium emanation, there is a spray of radiations in all directions, and although the alpha rays have very little penetrating power, and never succeed in getting beyond the glass walls of the tube itself, the beta and gamma rays pass through the glass and penetrate to various depths of tissue. Now, because of the relatively small penetrating power of the beta rays, they are absorbed to a large extent by a thin layer of tissue. The gamma rays pass beyond this zone and reach the outlying cells; but the dispersion of rays is increased the greater the distance from the source, so that the more distant gamma ray effect is comparatively slight, and less sharply defined than the beta ray effect. The area of radiated tissue does not increase in direct proportion to the amount of radium present; for if the radium is doubled the rays are not able to produce lethal effects twice as far into the tissues. When relatively strong tubes are used, the small depth of 5 mm. of tissue about the tube, i.e., 1 cm. in diameter, is radiated for a longer time than is necessary to produce the death of the cells, and we believe that in most cases this is not desirable.

The gamma ray effects, which occur farther away from the tube and appear later in time, are no doubt somewhat greater from relatively strong tubes, such as 5 mc., than from tubes of about 1 mc. each; but it has been difficult to test this point because of the prompt reduction in total size of any such treated tumor. It is possible that the tissues have a considerable amount of tolerance for the more penetrating radium radiations that reach beyond the 1 cm. zone, and this, together with the relatively small amount of radiation reaching this tissue, would account for the fact that there were but slight degenerative changes beyond the 1 cm. zone.

With comparatively large value tubes there is always the possibility of the tubes migrating during any sloughing that may occur, resulting in erosion of the walls of large blood vessels beyond the tumor proper, with attending hemorrhage; or the tubes may come to rest near some large nerve, and there set up a painful inflammatory process. This is of considerable importance when the lesion is in the neck or axillary regions, and a certain amount of motility of the parts tends to aid in the further displacement of the emanation tubes. This consideration is of especial significance in the treatment of carcinoma of the hollow viscera, stomach, bladder, etc., since the comparatively strong tubes, after causing a local slough, may be discharged by spasmodic muscular contractions at a time when they are still sufficiently radio-active to set up irritation elsewhere in normal tissue, and in the case of the stomach may result in violent prolonged vomiting; and in the bladder the misplaced tubes may injure the normal mucosa. In this connection, the use of comparatively weak radium tubes, i.e., those of 1 mc. and less in strength, has a distinct advantage, in so far as the tendency to slough out of position is greatly diminished; and if they are discharged after a few days they are not so likely to produce disagreeable effects in the normal tissues.[6] When one considers the fact that these tubes have an average life of 132 hours,[7] it will be seen that even when using

[5] Joly and Stevenson. *Proc. Roy. Dublin Soc.*, May 8, 1914. *Brit. M. J.*, July 4, 1914.

[6] The writer was interested in noting that Dr. Robert M. Lewis of Baltimore, who recently reported his methods for the insertion of unfiltered radium emanation, mentioned the fact that he was still using radium tubes of 2 and 5 mc. strength. (R. M. Lewis. *Surg., Gynec., and Obst.*, xxx, May, 1920.)

[7] The 132 hours is a mathematical factor, which when multiplied by the number of millicuries, gives the mc. hrs. of total irradiation. Thus if a tube of 0.5 mc. is inserted in the tissues the total dose of radium which is given is $0.5 \times 132 = 66.0$ mc. hrs. It should be noted, however, that the same dose in millicurie hours of a larger amount of radium for a correspondingly short length of time, will give a much more violent reaction.

tubes of less than 1 mc. strength, the tissues received a considerable amount of radiation.

CONCLUSIONS

1. These experiments have definitely indicated the therapeutic advantage of the treatment of certain cancers by means of small unfiltered glass tubes containing relatively little radium emanation per tube.

2. Less than 1 mc. is a satisfactory dose; in fact, 0.5 mc. per tube was found to be a most advantageous amount to use. When only a small supply of radium is available this is of considerable practical importance.

3. In order to treat effectively a given mass of tumor tissue with an even distribution of radiation, the emanation tubes should be imbedded about 1 cm. distance apart.

4. Interesting histological changes have been noted; and of especial interest was the presence of a pronounced leuffocytic infiltration, which tended to wall off the necrotic area about the emanation tubes.

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THE X-RAYS IN THE TREATMENT OF FIBROMATA AND UTERINE HEMORRHAGES*

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THE value of roentgenotherapy in the conservative treatment of uterine fibromyomata and of uterine hemorrhages is to-day well established and universally recognized. It constitutes, in fact, the treatment of election in these two pathological conditions, provided that there exist no infectious or cystic complications and that there is no accompanying disease of the adnexa.

This question of the roentgenotherapy of uterine fibromyomata has excited a great deal of discussion. Some over-enthusiastic roentgenologists believe that in the *x*-ray method is found a unique and unequalled treatment for all uterine fibromata, while others admit that surgery is suited to a few exceptional cases, and to cases where, for particular reasons, it is not convenient to administer roentgenotherapy. On the other hand, many eminent surgeons refuse to recognize the success of roentgenotherapy, relegating it to the groups of simple palliative measures already well known. The truth lies in a modification of these opinions, each of the two processes having its advantages. It is necessary first of all to be able to weigh the indications.

Surgical intervention will ever remain the treatment of choice in dealing with very large tumors which may give rise to grave pressure symptoms, tumors of rapid growth, pedunculated tumors, tumors complicated by cystic or inflammatory lesions of the adnexa, or those undergoing a process of malignant degeneration.

Roentgenotherapy is employed most successfully in the following cases:

1. In small, simple fibromata characterized only by a sensation of weight or fatigue in the lower abdomen, with menorrhagia.

2. In large fibromata, palpable through the abdominal wall, rising perhaps as high as the umbilicus, and accompanied by such symptoms as mechanical type of *constipation*, very difficult to overcome, due to pressure on the iliac colon; *frequent micturition*,

*Thesis presented with application for membership in THE AMERICAN ROENTGEN RAY SOCIETY.

due to diminution, by pressure, of the capacity of the bladder; *lumbar and sciatic* pain, due to pressure on the lumbar and sacral flexures. The menstrual periods may be normal as to the amount of flow and duration, or may be slightly increased in both.

3. In fibromata of any size accompanied by more or less severe hemorrhage.

4. In uterine hemorrhages of non-infectious origin, and in certain painful menorrhagias, without demonstrable fibroids.

5. In uterine hemorrhages with subinvolution, or in the hemorrhages preceding a delayed menopause.

In all of these cases, the results obtained are such as to be best represented by the words "cure," or "clinical cure," provided that the dose administered has been considerably more than that actually necessary to produce the menopause.

Very numerous observations have been published. I will not recall them here (their simple enumeration would require too much space), but shall content myself with citing the conclusions of some of their authors. In October, 1913, in the *Archives d'Electricité Médicale*, Dr. A. Béclère, the eminent roentgenologist of the Hôpital St. Antoine, Paris, published some remarkable statistics including 66 cases. "My statistics," he says, "are very favorable, showing success in 96 to 97 per cent of the cases; but I am far from attributing any merit to myself. The principal factor of success arises from the fact that the majority of these cases were referred to me by such gynecologists as Bar, Champetier de Ribes, Labadie, Lagrace, Lepafe, Pinard, Ribemont Dessaignes, and Siredey, or by such surgeons as J. L. Faure, Gosset, Perier, Ricard, Rochard, and Roux. In each case it was after a careful study of the therapeutic indications and contraindications that roentgenotherapy was judged preferable to surgical intervention."

In their conclusions, Bergonie and Speder write: "In the treatment of fibromata, the first noticeable modification of the menses and the hemorrhages was observed in less than two months of radiation. The menstrual periods become normal at once, then their duration and their amount decrease. After three or four series of radiation, rarely five, the menses and the hemorrhages cease.

"The fibromata always decrease in size, but in various degrees. In certain cases we have observed the complete disappearance of the tumor; in others, where an enormous tumor rose above the umbilicus, it diminished to two or three finger-breadths above the pubis, where it remained, unaffected by further treatment. The general condition is improved, the anemia ceases, the phenomena of compression disappear and the patients take up their occupations and their daily lives without the slightest discomfort.

"Roentgenotherapy presents not the least danger; with proper technique, the employment of the proper quality of rays, and a sufficient interval between the series, there is no danger of injuring the skin."

Bordier says: "Roentgenotherapy gives results which no radical method, electrical or otherwise, has ever afforded. But I hasten to add that if one follows a poor technique, one will obtain no better results than with other medical methods."

Insisting on the necessity of proper technique, Bordier adds that "it is so important that it is the dominant factor in the roentgen treatment of fibromyomata." This technique owes its success to three principal factors:

1. The judicious choice of the bundle of rays employed.

2. The measurement of the dosage.

3. The quality of rays emitted by the tube.

Are all women equally sensitive to roentgenotherapy? Until recently, roentgenotherapy was advised only for women who had reached or passed the menopause, that is to say, women aged forty or more. Younger women may have occasionally derived benefit from *x*-ray treatment, provided that it was continued long enough, and in an intermittent manner. But it is possible to-day, thanks to new technique, to induce the menopause artificially in young women seventeen

to eighteen years of age, or even in young girls at puberty, if there is a therapeutic indication for it.

It must be noted, however, that the treatment of young women is necessarily more prolonged than that of older women, the time required being in inverse proportion to the age of the patient. It is also necessary to warn young women that roentgenotherapy may produce in them a more or less definite sterility.

More than four years ago, at the Notre-Dame Hospital, I treated a young woman, aged twenty-five, who had a small hemorrhagic fibroid. Her menstrual periods were so painful that she was often obliged to remain in bed. An operation was advised, but was persistently refused. Her doctor, who was treating her for certain nervous troubles, induced partly by her gynecological condition, referred her to me. Under roentgenotherapy the hemorrhage subsided rapidly, and her menstrual periods ceased. The fibroma disappeared completely. I have seen this patient at regular intervals, in order to follow the results of the treatment. After twenty-seven months of menopause, she had a normal menstruation, and three months later, a second. Except for a few "hot flashes" during the first weeks, the patient experienced no symptoms attributable to this artificial and probably definite menopause.

One often encounters the following objection: "Don't you believe that there may be some danger in leaving *in situ* a uterus thus atrophied or sclerosed? Don't you think that later it may develop into a cancer?" This question arises from a theoretical fear which may be legitimate in itself, but which, nevertheless, remains hypothetical. Personally, I have never known of a case of uterine cancer developing after roentgen treatment for fibromyomata. If the cancer existed before the treatment, either alone or as a complication of the fibroma, we have seen that surgical intervention was indicated, leaving the *x*-ray to be employed as an adjuvant. Whenever and wherever I have met an experienced roentgenologist, I have never failed to put this question to him, and the reply has always been in the negative. Meanwhile, the first cases of roentgenotherapy for uterine fibroids date back seventeen or eighteen years in Europe, and I have before me a report by Dr. J. E. Hett of Berlin (Kitchener), Ontario, of a patient treated in January, 1903 (seventeen years), and published in September, 1904, in the *Journal of Advanced Therapeutics,* having for title: "The Complete Absorption of a Large Uterine Fibroid by *X*-Rays."

This danger, while remaining rare and remote, would be largely compensated, even if it existed, by the numerous advantages which this conservative method offers over surgical intervention.

What, then, are the principal advantages of roentgenotherapy when it is indicated?

1. The elimination of what risks there may be from an anesthetic. Roentgenotherapy, in fact, contrary to the process of electrolysis (method of Apostoli) is so absolutely painless that the patient is always astonished to learn that the treatment is finished.

2. The elimination of the possibility of post-operative hernia, internal hemorrhages, suppuration, or adhesions necessitating a second operation.

3. The patient loses no time by being bedfast, the treatment demanding only a few minutes every three or four weeks. In the intervals between the series, she may attend to all of her ordinary duties, and she has no need of special care.

4. One does not find in women treated by the *x*-rays that peculiar psychic or mental condition, nervous perhaps, observed after removal of the uterus or ovaries.

5. Roentgenotherapy offers absolutely no danger of roentgen dermatitis or ulceration, if a proper technique is employed.

6. Finally—and this is not the least of its advantages—roentgenotherapy has no mortality percentage.

It is objected that roentgenotherapy, although a sure method when indicated, is a little slow, and that surgery cures the patient much more promptly. When the patient leaves the operating room she has no

fibroma, it is true, and if she were not obliged to "recover from her operation," we should be forced to admit that surgery is more rapid; but if one takes into account the three or four weeks of hospitalization, and the weeks of rest and recuperation at home, supposing everything to go well (for in case of complications the time must be counted in months), the advantage remains with roentgenotherapy, which neither hospitalizes nor weakens its patients. This last advantage is more appreciable in the case of women who, because of their domestic obligations, would be unable to take a complete rest for several weeks.

My own statistics include forty-four cases. Seven of these were large tumors, with profuse and frequent hemorrhages, incapacitating and exsanguinating the patients. The ages varied from thirty-seven to fifty-five years. The tumor disappeared completely in the majority of these cases; in the others the reduction was incomplete, but nevertheless sufficient to suppress all of the disagreeable clinical symptoms in from three to six months. There was a complete cessation of hemorrhages and the establishment of a definite menopause in all of these cases except one, in which special circumstances forbade the continuance of the treatment. This case had hemorrhages of such gravity that it was necessary to administer, before the *x*-ray treatment, an injection of a coagulating serum. A second injection being attended by grave anaphylactic symptoms, it was necessary to suspend temporarily the roentgenotherapy. The patient was without hemorrhages for six weeks, but as she refused to remain in the Notre-Dame Hospital, and as she was obliged to remain in bed, she was unable to receive the roentgenotherapeutic applications which, without the least doubt, would have established the menopause. At the end of six weeks, she had a copious hemorrhage, and underwent an emergency operation. At the operation there was removed a large classical fibromyoma, exactly of the sort best treated by the *x*-ray. Twenty-two of my cases were those having habitually profuse menstruations, and occasional alarming hemorrhages. The size of the tumor varied from about the size of an orange to one large enough to rise to the umbilicus. The ages varied from twenty-five to sixty. In twenty cases the treatment produced a definite menopause, with no later return of the menstrual function; in one case menstruation reappeared twice, the first time after twenty-seven months, the second three months later. This case would seem to indicate that the menses may return in young women, if the dose administered was just sufficient to allay the principal symptoms. In seventeen cases the fibromata disappeared completely. In four cases there was a considerable decrease in the size of the tumor, and the patients remained symptom-free.

One of these last cases was that of a young woman, aged thirty-three. She was referred to us, with the diagnosis of fibroma, by her family physician. The diagnosis was confirmed by an eminent surgeon, who advised operation. The patient presented a large mass in the right iliac fossa, palpable in the vagina. She complained of pain low in the abdomen. Her menstrual periods were of long duration, profuse and frequent, occurring every three or four weeks. By advice of her physician, we commenced roentgenotherapy, but after the fourth application we discovered the tumor was growing. We advised her to consult a surgeon, and to undergo an operation if he thought it advisable. At operation there was discovered a fibromyoma complicated by an ovarian cyst, and a small dead fetus. If the diagnosis had been made correctly we would not have treated this patient, as roentgenotherapy was contraindicated.

Six cases were those having more or less normal menstrual periods. The principal symptom was pain in the lower abdomen, increased at the time of menstruation. The tumors varied in size from the size of an orange to that of a child's head. The ages were from thirty-four to forty-nine. The treatment produced definite suppression of the menses in all the cases, complete disappearance of the tumor in the majority of them, and a considerable decrease in the size of the

growth, accompanied by relief from all symptoms in the remainder.

Two were large fibromata in women who had no menorrhagia, one being eleven years and the other four years past the menopause. The first patient, aged fifty-nine, had a very large fibroid which, because of its great mobility, was believed to be pedunculated. She insisted on being treated by the *x*-ray, in spite of my advice to undergo a surgical operation; but as her condition was no better after three series of treatments, I abandoned the treatment. The second patient, aged forty-eight, had had no menorrhagic losses for four years. Her tumor rose a hand's breadth above the pubic bone. Under roentgenotherapy the growth disappeared behind the pubes, and although the uterus remained a little enlarged, all the painful symptoms vanished.

Two cases were women with large subinvoluted uteri, who were suffering profuse hemorrhages. No fibromata could be demonstrated. Roentgen treatment produced the menopause in each case.

Five cases were women having hemorrhages, whose uteri, however, were apparently normal in size. Roentgenotherapy produced a definite menopause in four cases. In the fifth case, that of a woman of forty, the menses ceased and the nearly intolerable pains disappeared after five series. For economic reasons she thought herself obliged to discontinue the treatment somewhat prematurely. The patient had neither menses nor pain for five months, and congratulated herself on having attained the menopause with a minimum of radiation. But after five months, a painless menstruation occurred, which decided the patient to receive another application. We warned her that she could not hope to obtain a definite menopause with less than 8 or 9 series, especially since she had suspended treatment for several months. She refused to submit to longer treatment, however, and after the appearance of another menstruation, two months later, she concluded that the method was a failure. I cannot agree that this case is a failure. On the contrary, the prompt cessation of the menses and the relief from pain during five months, after five applications, is in reality, a notable success. I have not the least doubt that two or three further applications would have produced a definite menopause in this case as in the four other cases of this series.

I have excluded from these statistics the case of a woman, single, aged forty, who was referred to me by her family physician in November, 1917, with the diagnosis of a large uterine fibroma. The patient presented a large hard tumor rising to the height of three finger breadths above the umbilicus, and somewhat more developed on the left side. She had very marked pain in the legs and an obstinate constipation, but neither urinary symptoms nor hemorrhages. The correctness of the diagnosis seemed doubtful to me at the time; but guided as much by professional courtesy as by the fear of the always possible error, I refrained from communicating my doubts to the patient, and I administered three series of treatments, which had no apparent effect upon the tumor. I referred the patient back to her physician, calling the attention of the latter to the probability of the tumor being a large cyst of the ovary. The doctor, concurring in this opinion, advised operation, which was obstinately refused, and the cyst was finally emptied by abdominal puncture. The greater part of the mass now disappeared, but another hard tumor could still be palpated in the right iliac fossa. The doctor was convinced that this time we had to deal with a fibroma, and again advised treatment by the *x*-ray. The first series was given the 23rd of February, 1918. On March 30th, the patient presented herself for the second series, and I found that the tumor had completely disappeared. By April 26th, the tumor had returned to approximately its volume of February 23rd. On May 24th the fourth series was given, apparently without influence on the tumor, from which I concluded that doubtless we had to deal with a second cyst, and I advised the patient to undergo an operation, as roentgenotherapy had not the least chance to effect a cure. To this she consented and at operation a rather large ovarian cyst

was found. The uterus was apparently normal, showing no trace of the fibroma.

My personal statistics are thus shown to be in perfect agreement with those of our masters. We find from them that the symptom of hemorrhage, the most alarming to the patient, and usually the symptom that decides her to consult a physician, disappears unfailingly provided that the dose of radiation absorbed has been sufficient.

As to fibromata, they disappear completely in the great majority of cases. In the other cases they undergo a well marked retrogression which is nearly always sufficient to cause the disappearance of all the symptoms of pain and of compression of the intestines and bladder.

In the 44 cases which I have presented, 41 were clinical cures and 3 were failures; that is to say, 93 per cent of success. Two of the failures were due to a diagnostic error, the third failure should be imputed to the patient rather than to roentgenotherapy, since the patient, after the treatment advised in 1915, did not call upon me until a year later when she was literally dying of hemorrhage. After the third series of treatments she experienced relief from all symptoms for six weeks, and had she been willing to remain in the hospital and to have received at least three more applications, she would have been freed, I am certain, from the danger of further uterine hemorrhage.

I feel convinced that we may be assured of a brilliant result in every case where the diagnosis has been made correctly.

Personally, I feel so assured as to the results to be obtained that if the patient does not experience a marked improvement after the third or fourth series I do not hesitate to affirm that the diagnosis is incorrect and that it is not a case of fibroma, or that, if the fibroma is present, there are at the same time adnexal complications which can be cured only by surgical intervention, and I do not hesitate to refer those patients for surgery.

INFLAMMATORY LESIONS OF THE ADNEXA

Radiotherapy is ordinarily contraindicated in inflammatory lesions of the tubes or ovaries.

I have, however, made an interesting observation on a patient seen in consultation with a surgeon in September, 1913, which is worth relating here.

The case is that of a young woman, twenty-seven years of age, having suffered profuse and painful menstruation for two or three years. There was no history of a Neisserian infection. For some months the pains had been very persistent in the right iliac fossa, even between the menstrual periods. On the day that I saw the patient with her surgeon she was unable to leave her bed, was suffering considerably, and had a temperature of 102 degrees. The right iliac fossa was very tender and felt very hot to the touch. Vaginal examination revealed a hard painful mass in the right side. The diagnosis lay between appendicitis and adnexal lesion. However that may be, rest in bed, and ice applied to right iliac region, lowered the temperature and relieved the pain in a few days.

At the end of fifteen days the patient was much better, except for slight tenderness in the right side. Vaginal examination at this time revealed a large fluctuating mass in the cul-de-sac of Douglas. There was no temperature. There was slight tenderness and some heaviness in the right iliac fossa; operation was advised but was refused. At the patient's menstrual period all the symptoms returned, temperature rising to 100 degrees and subsiding again after ten days.

The patient persisted in refusing an operation and demanded that she be treated by roentgenotherapy. I warned her that there was considerable risk of re-exciting the acute symptoms, but she insisted nevertheless. Ten days after the first application all the patient's pain had disappeared and she felt as though the discomfort which existed in her right side were vanishing. The second application relieved the pain completely, even palpation becoming painless. The menstrual periods following, to the patient's great surprise, were practically painless and lasted only four days. Two other series were given

at intervals of fifteen days, at the end of which time the patient declared she had never felt better. The third vaginal examination revealed, to the great surprise of the surgeon, that the cul-de-sac was entirely free and that there was no tenderness whatever in that region. In short, everything seemed to him to be absolutely normal.

As I did not wish to produce an amenorrhea, I suspended the radiotherapy, keeping the patient under observation. The four menstrual periods following were normal, painless and regular. The fifth period was somewhat premature, more profuse, and rather painful. The sixth period was very painful and the right iliac fossa again became tender. Roentgen treatment was resumed; I made four applications at intervals of three weeks. After the first application, the pain ceased, and for the year following the patient had regular and painless menstrual periods. Then, following a prolonged exposure to inclement weather, the patient had two painful periods. Four more series of roentgenotherapy were given, and for two and a half years the patient has experienced no sort of pain in spite of frequent exposure to all sorts of inclement weather. It is worthy of note that three or four times a year the patient misses a menstrual period, having in its place, "hot flashes." It is quite probable that in this case the right ovary is sterilized.

I do not wish to draw, from this single observation, any conclusion as to the value of radiotherapy in inflammatory lesions of the adnexa. I say adnexa, because I believe that the entire clinical history of this case points to disease of the adnexa rather than of the appendix. I believe it would be very interesting and well worth while to repeat this experiment in a case where, for some reason, operation was contraindicated.

The continuation of the menses in a person who has reached the age of the normal menopause may have a considerable reflex influence on some other pathological condition, as, for example, a nephritis or a disease of the stomach or heart where such is sufficient to render useless all our therapeutic efforts and endanger the life of the patient. In such cases the production of an artificial menopause may be considered as indicated.

The following case will serve as an illustration: Miss M., age forty-eight, suffering from a serious cardiac disease, was referred to us by her doctor. Orthodiagraphy showed a cardiac shadow measuring 128 square centimeters; an increase in area of about 50 per cent. The usual treatment for such conditions was effective in the intervals between the menstrual periods, but at the appearance of the menses the heart would become uncontrollable and the patient's condition would grow very serious. This condition of things existed for many years and the establishment of the menopause, which was expected to relieve these symptoms, was anxiously awaited. The menses reappeared, however, with disheartening persistency, each reappearance being a new menace to the patient's cardiac condition.

Roentgenotherapy was proposed and tried. A single application of the *x*-ray served to arrest menstruation and the patient experienced such a condition of well-being that she insisted on receiving several more treatments in order that the menopause might be definitely established.

The patient is still a cardiac patient, but the means of combating the symptoms of her affection have acquired a new efficacy.

These observations would seem to imply that in the *x*-ray we possess a method of incontestable efficacy for the treatment for some of the diseases of women.

I cannot better conclude this summary than to quote the conclusions of a physician of thirty years' experience. In his inaugural address given December 13, 1917, before the North London Medical Society, Sir John Phillips, M.A., M.D., F.R.C.P., Surgeon to the Queen of England, Professor Emeritus of Obstetrics at the Royal College, said: "All varieties of fibromata correctly diagnosed as such may be successfully treated by the roentgen ray. I may say that my personal conviction is, that we have in the *x*-ray

a very powerful therapeutic agent which promises to be of an inestimable value in the treatment of the diseases of women."

TECHNIQUE

In the great majority of cases I have employed the technique described by Dr. Béclère; that is, the radiation of the two ovarian regions, directing the rays obliquely through the uterus, using only two anterior ports of entry. In women more than forty years old the arrest of the hemorrhage and of the menstrual function was obtained after the third or fourth application, parallel gap of 20 to 22 cm.; three millimeters of aluminum for filtration; radiant energy equivalent to 16 X. In women fifty years of age such a dose produced the menopause; in one case after the first treatment, and in three cases after the second treatment. In younger women aged from thirty to forty years, the menopause was not established until after the fifth, sixth or even the seventh application.

As to fibromata, the number of applications required to make them disappear varied from five to ten series, according to their size and age. The majority of these tumors disappeared entirely; in certain cases the uterus was found to remain a little enlarged.

In the cases of very large tumors, some of them disappeared completely; seven or eight underwent retrogression to such a degree that they disappeared behind the pubis, the uterus remaining somewhat enlarged. The patients, however, complained of no discomfort and were clinically cured.

One case of a large pedunculated fibroid seemed to be quite unaffected by radiotherapy, and the treatment was abandoned.

In some cases where it seemed desirable to produce prompt results, either because of the abundant hemorrhages or to avoid obliging patients in the country to make such frequent visits to my office, I have used four ports of entry, two anterior and two posterior. The effects have been much more rapid in these cases. The intervals between the series were three, four and five; in some grave cases the first application was repeated in 15 days.

Finally, in some cases, I have tried the method of multiple port of entry; eight anterior and eight posterior. It did not seem to me that I obtained the menopause any more rapidly by this procedure than by the method of Béclère, which is much more simple. On the contrary, with this method of several ports of entry, I have noticed that the patient experienced malaise, vertigo, nausea or even vomiting from the first series of applications, and that these symptoms are much more marked and more annoying to the patient than those occurring with the simple method of two ports of entry. In fact, with this last technique several patients experienced either no discomfort, or symptoms so mild that it was necessary to inquire about them before the patient thought of them. The majority of women, however, complain of vertigo and nausea after the third or fourth application. These symptoms increase in intensity with the number of successive applications, but except in one case they have not been sufficient to justify the cessation of treatment. Moreover, for two years I have confined myself entirely to this simple and efficacious method of two anterior ports of entry, which seems to offer the minimum of inconvenience.

In serious cases where immediate action is indicated I do not hesitate to give a dose of 30 or even 40 X with excellent effect upon the hemorrhage; but in these cases the general symptoms have been more marked.

The results obtained have been permanent, the earlier cases dating back eight years.

With thick filters the effect on the skin is nil; I have never observed telangiectasis. Some of my first cases which were treated with a 1 mm. filter of aluminum and with a parallel gap of 15 cm. have insignificant telangiectases, but no case has presented any induration or ulceration of the skin.

THE RATIONALE OF RADIUMTHERAPY IN CANCER*

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THE SPECIFICITY OF THE BIOLOGICAL ACTION OF RADIUM.

THE terms "selective action" and "selective absorption" are being employed more or less promiscuously in defining the peculiar influence which the *x*-rays and radium exert on plant and animal cells. In reality, the two terms imply different phenomena in the interaction between the rays and the cells.

The fact is well established that the biological effect of the rays on plant and vertebrate animal organisms differ within the various tissues. While the spermatozoa-forming epithelium and the Graafian follicles, for instance, are extremely sensitive to the rays, nerve tissue and the structures of the eye are highly resistant.

The cells most sensitive to the action of radium and *x*-ray are the leukocytes, and these cells present the most favorable material for the study of the "selective action" of the rays.

In a case of lymphatic leukemia with an initial leukocyte count of 226000, an enlarged spleen without any enlargement of the lymph glands, the writer made two applications of radium to the spleen within a week, 2016 millicurie-hours in all. The leukocyte count came down to 12000 and the spleen diminished to a half of the original size.

Figures 1 and 2 show the blood pictures before and after radium applications to the spleen of another case of lymphatic leukemia. In this case there were large lymph glands in the axilla and the spleen reached below the umbilicus. After radium treatment the spleen and glands diminished in size and the leukocyte count went down from 180000 to 50000.

This rapid destruction of a specialized tissue by an external application of radium to the spleen which was not followed by even an erythema of the skin in the field of application, presents a remarkable biological phenomenon indeed.

The "selective" biological action of radium goes beyond the apparent structural differences of the cells. The lymphocytes of lymphatic leukemia and those of conditions of inflammatory leukocytosis are morphologically identical. None the less, radium destroys rapidly the former and has a comparatively slight effect on the latter. The same difference may be noted, for instance, between a lymphosarcoma of a lymph gland and a tubercular lymphoma. The latter condition is influenced by radium with much greater difficulty than the former.

Another proof of the remarkably fine adjustment of the "specific action" of the rays on cells was obtained by the writer in the course of a study of the blood of cases of skeletal metastases of carcinoma treated with radiations.

Radium and *x*-rays reduce rapidly the number of myelocytes in the blood of cases of myelogenous leukemia. The blood of cases of skeletal metastases of carcinoma also frequently contains an increased number of myelocytes in the blood. These latter myelocytes are not influenced by the rays, though they are morphologically identical with the myelocytes in myelogenous leukemia. The explanation of this phenomenon lies in the fact that the two types of myelocytes differ biologically. The myelocytes in myelogenous leukemia, as well as the lymphocytes in lymphatic leukemia, are analogous to cancer cells. They are young, rapidly proliferating cells and therefore highly sensitive to the rays. The lymphocytes in inflamma-

* Read by invitation at the twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., September 14-17, 1920.

tory leukocytosis and the myelocytes in the blood of skeletal metastases are more mature cells; they do not proliferate so rapidly and are therefore more resistant to the rays. Thus the term "selective action," means that *the identical rays act differently on different tissues.*

On the other hand, there is ample clinical evidence of the fact that rays of a different quality affect differently the same type of tissue. For instance, soft *x*-rays and alpha rays of radium act differently on the skin from the hard *x*-rays and the gamma rays of radium. Experimental evidence of the existence of this difference was obtained by the writer in a study conducted in collaboration with M. Levine.[1]

The investigation consisted in the study of the influence of the *x*-rays on the lymphocytes of a turtle. This animal was selected because it has comparatively little of skeleton and bone marrow, and as a result the main type of white cells in the blood are the lymphocytes. Very large doses of unfiltered *x*-rays were employed, and the whole body of the turtle was subjected to the rays. Differential blood count after treatment showed that the number of lymphocytes was reduced from over 95 per cent to as little as 16 per cent.

In a second series of experiments, two turtles were superimposed and both animals rayed in the same manner as in the first series of experiments. In the upper turtle of this series, the reduction in the number of lymphocytes was as great as in the first series of experiments, while the reduction in the lower animal was much less pronounced and always remained above 50 per cent.

In a third series of experiments, a dead turtle or a layer of meat was placed over the living turtle and the whole *x*-rayed. In this series of experiments, the only live turtle used was at the same distance and in the same relative position to the rays as the lower turtle in the second series. Since the general absorption of *x*-rays and rays of radium takes place in the same degree, whether the rays pass through a living organism, inorganic matter or water, then the only live turtle in the third series of experiments did not receive a greater fraction of the whole amount of general radiation than the lower turtle in the second series; but the percentage of destroyed lymphocytes was the same as in the upper turtle of the second series. The ex-

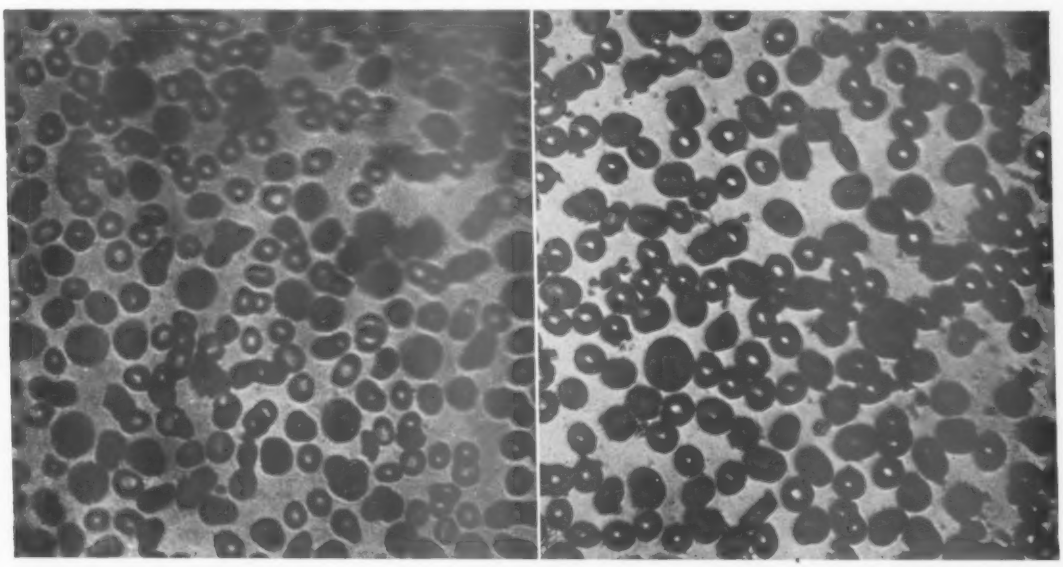

FIG. 1. MICROPHOTOGRAPH. BLOOD SMEAR OF LYMPHATIC LEUKEMIA BEFORE TREATMENT.

FIG. 2. MICROPHOTOGRAPH. BLOOD SMEAR OF LEUKEMIA AFTER TREATMENT.

planation of this phenomenon is as follows: The particular type of rays which is affecting the lymphocytes of the upper turtle became itself destroyed or "absorbed" in the course of its activity, and there was left a smaller quantity of this type of rays to act on the lower turtle; while in the third series the meat of the dead turtle did not contain any living lymphocytes which could "absorb" the special type of rays, and the whole amount acted on the live turtle which lay under the dead animal.

Variations in absorption of different types of rays have been shown by physical research to be true for metals, and the same is evidently also true for living tissues. Thus in contradistinction to "selective action" the term "selective absorption" means that *the same tissue may destroy or "absorb" one type of rays and not influence another.*

THE SIGNIFICANCE OF "SELECTIVE ACTION" OF THE RAYS IN THERAPY.

Both the phenomena of "selective biological action" and of "selective absorption" are of great importance for the estimation of the therapeutic value of the rays. The true valuation of the "selective absorption" cannot be obtained until a great deal more research shall have been undertaken as regards the best types of the rays, methods of filtration and correct distance to be applied in therapy. It is fairly well established, however, that the harder rays have a more selective action on the tissues than the softer rays. It is therefore self-evident that the action of radium must be different qualitatively from the *x*-rays and must be more beneficial for therapy.

The "selective action" of the identical type of rays on various tissues is a phenomenon of the greatest importance in therapy and places ray treatment on an equality with true specific methods of treatment, like salvarsan, mercury or quinine.

Furthermore the adjustment is even finer in ray therapy than in chemiotherapy. The chemical substances in the latter methods of therapy act on parasites which differ to a greater extent from the body cells of the host than do the tumor cells from the normal tissue cells.

The great practical value of this "selective action" of the rays consists in the fact that large quantities necessary for the treatment of malignant tumors may be employed without injuring the adjacent normal tissues. The following case indicates how well normal tissues may resist large quantities of radium sufficient to influence a malignant tumor, when the rays are correctly filtered and applied at a proper distance.

Miss L. M., forty-three years old, single. Patient had right breast removed for carcinoma July, 1918. In June, 1919, she began to experience pain in right hip, which at first was intermittent, and from December, 1919, constant. *X*-ray examination showed metastasis in the head of the femur. About the middle of November, 1919, patient developed esophoria of the left eye. Ophthalmoscopic examination made in December, 1919, revealed the following condition:

Disc color normal, surface flat; no elevation or depressions. Arteries and veins normal in caliber. Peri-papillary area normal. Macular area free from any pathological process. At the upper and inner quadrant of the disc vessels appear to be blurred and can be distinctly seen with the 7D lens. From this area and extending to the periphery one sees apparently a protruding mass, globular in outline, with a complete ill-defined margin. Color of the mass slightly grayish, its surface shows lighter areas, apparently no elevations or depressions on the mass. No detachment of retina apparent, also no evidence of any hemorrhage or exudation in the fundus.

Diagnosis: Metastatic tumor of the retina.

On the same day treatments were begun and the following quantities were given.

Dec.	9, 1919	83.4 millicuries	applied for	5 hours.
Dec.	12, 1919	93.7 millicuries	applied for	6 hours.
Jan.	7, 1920	47.4 millicuries	applied for	8 hours.
Jan.	28, 1920	67. millicuries	applied for	19 hours.
Feb.	7, 1920	66.7 millicuries	applied for	6 hours.
Feb.	28, 1920	68. millicuries	applied for	10 hours.
Mar.	13, 1920	61.1 millicuries	applied for	12 hours.

At the last examination which was done in August, 1920, the area of the tumor on the retina was found to be less prominent, being only two to three D diameters elevation and passing more diffusely into the retinal structure. Apparently in the eight months since the first examination the tumor, if anything, diminished in size, and what is of greater importance, all the other tissues of the eye remained normal. In this case quantities of radium were applied to the eye sufficient to influence a large carcinoma mass, and neither the skin of the eyelid, the conjunctiva nor any of the tissues of the eyeball were impaired in any way.

FIG. 3. TO THE LEFT AN INOCULATED AND *X*-RAYED PLANT, showing at *b* a minute swelling at the point of inoculation. TO THE RIGHT AN INOCULATED CONTROL PLANT showing at *c* a fully developed crown gall. The plants themselves show no abnormality.

THE MECHANISM OF THE ACTION OF RADIUM ON CANCER

The fact that radium may destroy a malignant tumor without injuring the adjacent normal tissues is a true indication that radium does not act as a caustic but has a specific "selective action" on the tumor. What is the actual mechanism of this action? The microscopic analysis of cancer tissue submitted to radiation most generally shows marked degenerative changes in the tumor cells consisting in vacuolation of the protoplasm, pycnosis of nuclei, karyolysis, and ultimately complete necrosis of the cell. The cellular changes are accompanied by a round-cell infiltration, which is subsequently changed into dense sclerotic connective tissue, poor in blood vessels. This new connective tissue formation ultimately dominates the picture to such an extent that some observers maintain it is the only direct effect of radiation, while the destruction of the tumor cells is secondary and due to lack of nutrition.

In order to ascertain whether the rays have a direct effect on the tumor cells, the writer has undertaken in association with M. Levine,[2] a study on the influence of *x*-rays on the crown gall. This disease is a new growth which develops spontaneously or may be induced artificially in various plants. It presents an ideal subject for the study of the direct influence of the rays on the tumor cells, since plants do not possess any lymphoid tissue. As a result, no connective tissue forms, and the behavior of the tumor cells can be studied unobstructed. The results of this investigation show that the rays arrest the development of the tumor. While in all

the untreated control plants, there developed a large crown gall, the majority of the *x*-rayed plants did not develop any growth, and only a slight swelling appeared at the place of inoculation. (Figure 3 shows a

FIG. 4. AN INOCULATED AND *X*-RAYED PLANT, shows at *b* a stunted crown gall.

treated plant and a control.) In a few plants there developed a small stunted growth. (Fig. 4.)

The microscopical study of the radiated plants revealed a very instructive condition. Not only the stunted growths but even the minute swellings which on inspection were thought by the writer to be scars caused by the mechanical injury of the needle prick, showed the presence of morphologically unchanged crown gall cells. Figure 5 shows a fully developed crown gall, and Figure 6 shows a small group of crown gall cells in a minute swelling of a petiole (the stem of a leaf). This investigation as well as the clinical and pathological studies of the writer indicate that the first effect of the rays is exerted directly on the tumor cells. This effect consists in the inhibition of the proliferating power, in the *sterilization*, as it were, of the cancer cells. The degeneration and destruction of the cancer cells and the formation of the sclerotic connective tissue take place subsequently through the action of the rays; moreover this cell degeneration and cell death may not be due directly to the action of the rays, but takes place in the natural course of the life cycle of the cancer cell. This cycle consists of *youth*, or period of development; *maturity*, or period of function; and *senility*, or period of degeneration, which gradually leads to death. In parenchymatous organs, like the liver and kidney, the first period is usually completed during embryonic life or at very early age; the second period continues through the whole life of the organism, and the third period is attained at the old age of the organism or near its death.

The life of an individual cancer cell, on the other hand, is very short; it changes rapidly from an embryonic into an adult and then immediately into an aged, degenerated cell, and this process takes place continually, irrespective of any extrinsic aid. But in a malignant tumor the majority of the cancer cells are quickly rejuvenated before they reach senility through the fact that each cancer cell divides into two young daughter cells. When the rays arrest this proliferation, then the cancer cells, without any further

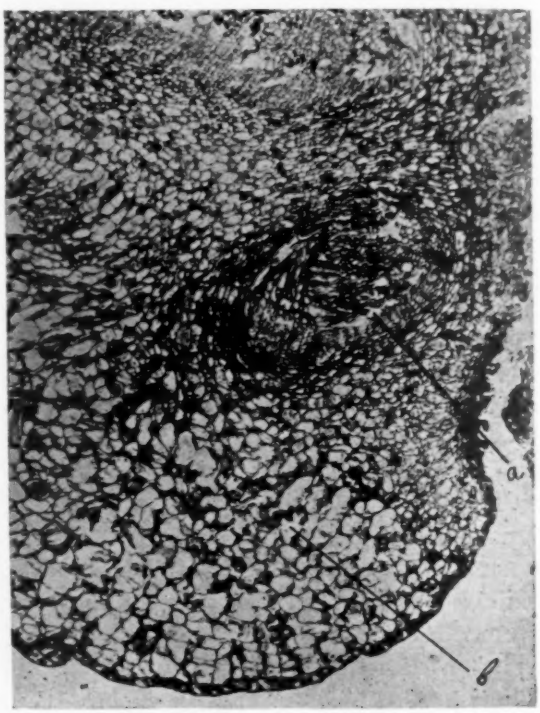

FIG. 5. MICROPHOTOGRAPH. CROWN GALL. *a* shows tumor cells, *b* normal stem cells.

outside aid, mature and degenerate. It is interesting to note in this connection that the life of the epithelium of the skin or testicle is nearly as short as one of the malignant tumors, and the rays act on these organs as specifically as they do on malignant tumors. Thus the inhibition of the proliferating power of the cancer cell and its ultimate degeneration and death constitute the primary and main action of the rays on a malignant tumor.

The round cell infiltration, which surrounds the groups of radiated cancer cells and which is subsequently changed into dense sclerotic connective tissue, is of secondary occurrence, though for practical purposes it is of greater importance than the destruction of the cancer cells themselves. The importance of the connective tissue consists in the following. After the most perfect results of radiation, there may remain a certain number of viable though stunted cancer cells; the dense connective tissue wall surrounds these cells and keeps them in check.

THE RÔLE OF THE NEWLY FORMED CONNECTIVE TISSUE.

The formation of the connective tissue around the rayed cancer cells is not due to the direct influence of the radiations, and raying of other conditions like thyroid gland, cheloid, etc., is not followed either by cell infiltration or by connective tissue formation.

The experimental investigations of the writer [3] indicate that this connective tissue formation may represent an attempt by the organism to protect itself against the further growth of the cancer by walling it off from the normal tissues by a connective tissue barrier.

In a series of experiments on inoculable cancers of the white rat, the writer has shown that when particles of the tumors were inoculated into internal organs (liver, kidney, brain, testicle and so on) of susceptible animals, the tumor grew diffusely, invaded the normal tissues of the organ, and there was no connective tissue formed around the graft. Furthermore the adjacent normal tissues became diseased [4] (fatty degeneration) under the influence of the growing tumor before they were invaded by the latter.

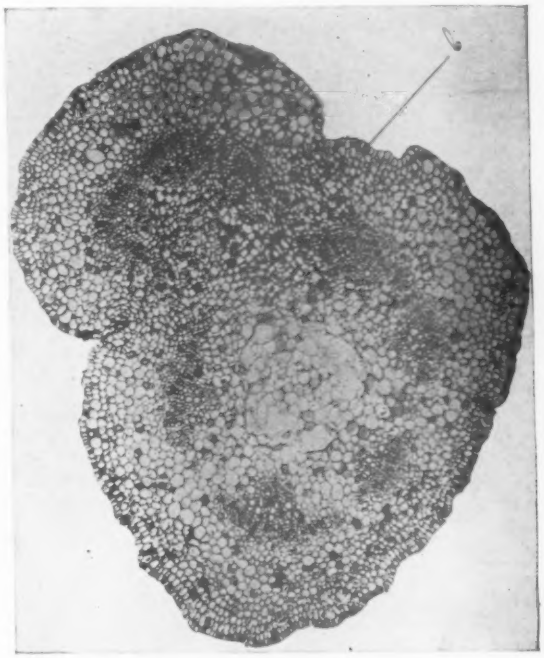

FIG. 6. MICROPHOTOGRAPH. CROSS SECTION OF A PETIOLE. Shows at *b* a small group of tumor cells.

In another series, the animals were made by a preliminary treatment resistant to the growth of the tumor, and then particles of the tumor were inoculated into internal organs. In these animals the grafted cancer tissue did not grow but was surrounded by newly formed connective tissue. Thus it appears that when the cancer cells are malignant and proliferate they also interfere with the formation of the connective tissue wall. When the animal is resistant it inhibits the proliferation of the cancer cells and creates at the same time a connective tissue barrier. A similar mechanism most likely takes place in the course of the raying of cancer tissue. The rays inhibit the proliferating power of the cancer cells and destroy their malignancy. The organism is then enabled to form

a protective connective tissue barrier around the tumor.

That this conception is plausible may be gathered from the fact that a number of

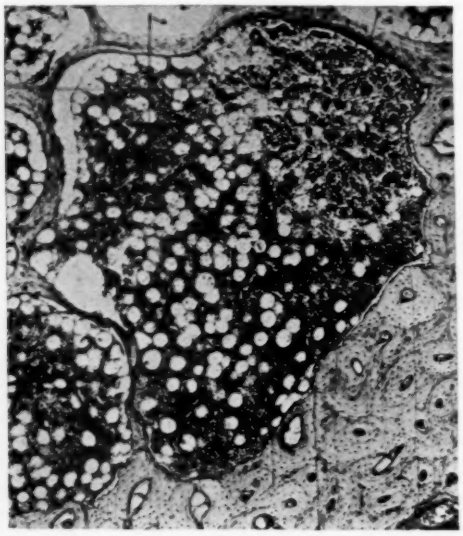

FIG. 7. MICROPHOTOGRAPH. MINUTE NODULE OF CARCINOMA IN THE BONE MARROW. *a* shows carcinoma; *b* normal marrow.

pathologists (Borst,[5] Schmidt,[6] Orth [7]) describe the same phenomenon as occurring spontaneously in the human. A connective tissue stroma surrounds a group of cancer cells, gradually increases in size, compresses

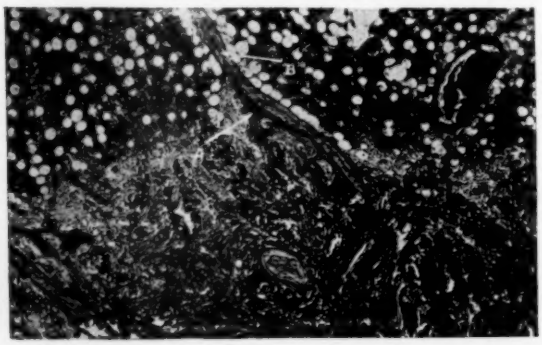

FIG. 8. MICROPHOTOGRAPH. SHOWS A GREAT DEAL OF NEW BONE FORMATION IN THE VICINITY OF AN OLD BRIDGE OF COMPACT BONE TISSUE. *b* shows old bone; *a* new bone.

the cancer cells and produces a local cure of the growth.

In other words radium and the *x*-rays perform with greater precision and by far greater frequency what the organism itself attempts to do haltingly and in rare instances.

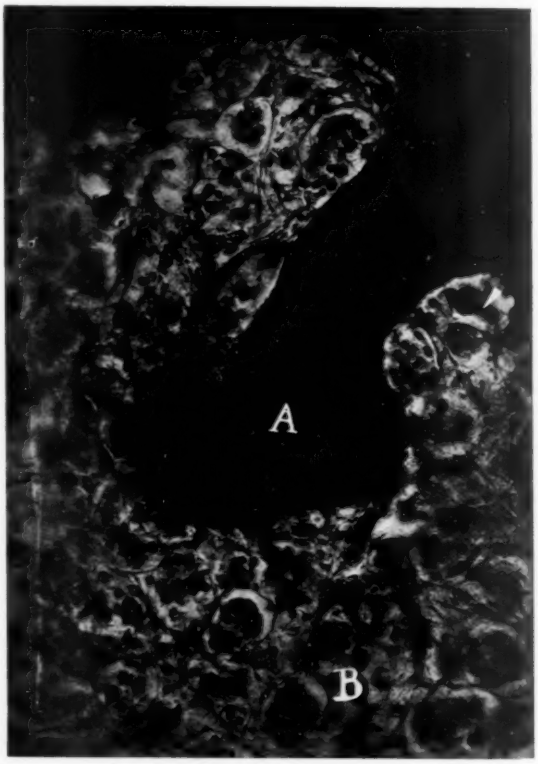

FIG. 9. MICROPHOTOGRAPH. TWO BONE LACUNAE FILLED WITH CARCINOMA CELLS. Low magnification. A shows bone; B carcinoma.

ACTION OF RADIUM ON MALIGNANT TUMORS OF THE SKELETON.

The mechanism of the action of the rays on malignant tumors, the sequence of events as well as the fact that results obtained through this action resemble the phenomena which occur spontaneously in the organism, can be demonstrated most clearly in the study of the influence which radium exerts on carcinoma and sarcoma of the skeleton.

In a pathological study of skeletal metastases of carcinoma, the writer [8] has shown that the metastasis usually begins its development within the marrow, and when the nodule of carcinoma is small, the surrounding bone-marrow appears quite normal (Fig. 7). As the tumor nodule increases in size, it

approaches and invades the compact osseous tissue or the compact osseous partitions of the cancellated bone. Then there begin to appear characteristic changes in the bone tissue. These changes are of two types, *osteoplastic*, in which extensive new bone formation takes place around the metastatic tumor, and *osteoporotic*, in which the changes consist in destruction of the compact bone. The studies of the writer have shown that both conditions are usually present. Figure 8 shows an extensive new bone formation, and Figure 9 shows only destruction of the old bone, and both specimens were obtained from different regions of the same metastatic tumor. The destruction of the old bone is caused mainly by the cancer cells themselves acting as osteoclasts, as is clearly seen in Figure 9. Figure 10 shows collagen fibrils formed from the old bone. These fibrils gradually unite in thick bundles and subsequently form new bone.

FIG. 10. MICROPHOTOGRAPH. MICROSCOPIC SECTION OF A SKELETAL METASTASIS STAINED WITH VAN GIESON. Shows Collagen fibrils emerging from the old bone and uniting with other fibrils.

Most frequently the metastatic nodule increases in size, suppresses the power of the organism to create new bone and progressively destroys the old bone. The spontaneous healing power of the organism is thus quite imperfect and comes into play very rarely indeed. In a previous communication the writer [9] has shown that radium therapy may enhance the healing power of the organism, destroy at least a major part of the malignant tumor, and surround it with newly formed bone. Further progress of this study may be reported here. The three cases reported in the previous publication are well to-day, six, five and a half, and five years respectively since the beginning of the treatment. Figure 11 shows the roentgenogram of one of the three cases five years since the beginning of the treatment. The metastasis in the spine—second and third lumbar vertebra—became manifest six months after a radical amputation of the breast. In November, 1915, the patient entered Montefiore Hospital, suffering from paraplegia dolorosa. At present the patient is clinically well.

FIG. 11. ROENTGENOGRAM. METASTASIS OF CARCINOMA IN THE SECOND AND THIRD LUMBAR VERTEBRA FIVE YEARS AFTER TREATMENT.

The roentgenogram taken in August, 1920, shows a good deal of new bone formation in comparison with the findings five years ago.

Figures 12 and 13 present two roentgenograms of the right clavicle of a boy seven-

FIG. 12. ROENTGENOGRAM. SARCOMA OF CLAVICLE.

teen years old who suffered from multiple sarcomata of the skeleton with metastasis in the lungs to which the patient succumbed. Radium was applied experimentally to the tumor of the clavicle. Figure 13 shows clearly that the tumor of the soft tissue disappeared, and a great deal of new bone was formed.

Figures 14 and 15 present roentgenograms of the spine of a woman twenty-seven years of age whose right breast was removed for carcinoma in November, 1918. A year later there developed a paraplegia dolorosa, the patient entered the Lenox Hill Hospital, roentgen examination showed destruction of bone of the fifth lumbar vertebra. On January 21, 1920, the first radium application to the affected bone was given. In August, 1920, seven months later, a roentgenogram (Fig. 15) was taken and it shows a good deal of new bone formation. At the same time the clinical condition of the patient is greatly improved.

THE ADVANTAGES OF THE USE OF BURIED EMANATION TUBES.

The data furnished in this paper indicate that radium exerts a truly specific selective action on cancer tissue. Biologically, then, radium therapy in cancer has a thoroughly scientific foundation and presents the nearest approach to a specific therapeutic measure against the disease. In practice, however, the action of radium has its limitations, and the results obtained thus far vary in accordance with the size and location of the tumor. The effectiveness of the rays diminishes in inverse ratio to the increase of the distance and the size of the tumor. A preliminary surgical removal of the main mass of the tumor, even when radical surgery is impossible, diminishes the difficulties in connection with the size of the tumor. The placing of the radium in near approximation to or within the tumor does away with the disadvantages which are presented by a greater distance between the source of radiation and the tumor.

FIG. 13. ROENTGENOGRAM. SARCOMA OF CLAVICLE AFTER APPLICATION OF RADIUM. Shows new bone formation.

A new method was recently developed by Duane of Boston which obviates to a great extent the difficulties created both by the size and location of the tumor. It consists in the use of buried radium emanation tubes.

Each minute glass tube contains not more than about 3 millicuries. A sufficient number of the tubes is buried in the tumor to cover its whole mass and is left there permanently. The emanation decays after a time and the tubes become inert.

While this method is simpler and frequently more efficient than the external application of radium, one must not lose sight of the fact that the action of the buried emanation is not as strictly selective as the external application of well-filtered rays. The emanation in the minute tubes is filtered only by the glass walls of the latter. Therefore the soft beta rays also act on the tumor and may produce small foci of necrosis around the buried tubes. Care must be taken, therefore, not to place the tubes too near the surface of the tumor nor too near large blood vessels or nerves. Neither must the emanation tubes be placed too near each other. But with correct technique this method will in the near future supersede the external application of radium in combination with incomplete surgery and become the method of choice in many conditions. The method of buried emanations should always be accompanied, however, by external application in the areas of the regional lymph glands and the areas directly adjoining the tumor.

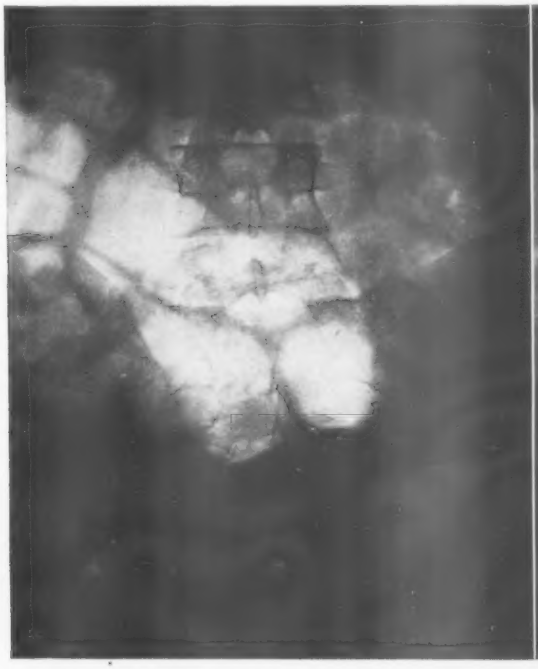

FIG. 14. ROENTGENOGRAM. METASTASIS OF CARCINOMA OF THE FIFTH LUMBAR VERTEBRA.

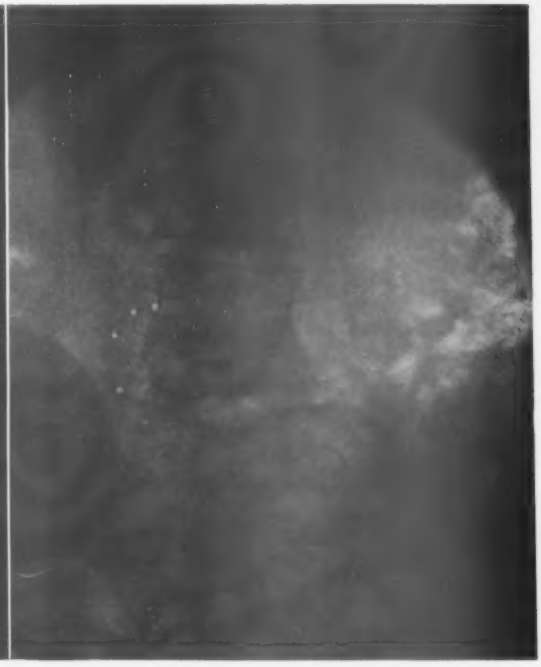

FIG. 15. ROENTGENOGRAM. METASTASIS OF CARCINOMA OF THE FIFTH LUMBAR VERTEBRA AFTER APPLICATION OF RADIUM. Shows new bone formation.

THE CORRECT FUNCTION OF RADIUM AND THE *x*-RAYS IN CANCER THERAPY.

There has developed in some quarters recently a tendency to apply to a cancer patient one intense dose of radium or *x*-rays which is not to be followed by another application for a long period of time, if at all. In this manner an attempt is made at a radical cure of the disease.

In the opinion of the writer, this method is erroneous and must be followed by many ultimate failures for this reason: As stated above, the first action of the rays on the cancer cell consists in the inhibition of the *pro-*

liferating power of the nucleus. As a result the cancer cell does not divide into two young cells but enters the state of maturity. Such a *matured* cancer cell or a *stunned* cell, as stated above, may remain alive and it is then probably as resistant to the rays as the adjoining normal tissue cells and may not be destroyed by the rays. None the less it is potentially a cancer cell, and it may recover

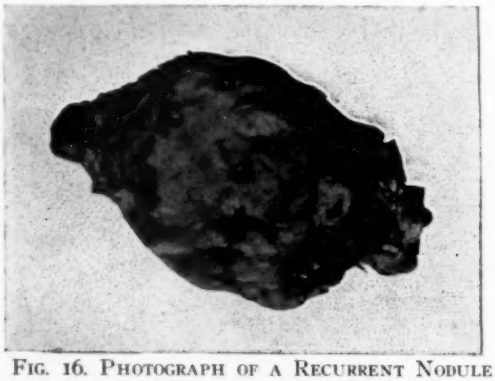

FIG. 16. PHOTOGRAPH OF A RECURRENT NODULE OF CARCINOMA TREATED BY RADIUM. Darker area on the surface presents new carcinoma tissue.

sooner or later its proliferating power and create a new tumor mass if it is not radiated repeatedly. Such a cancer cell in its matured state may appear on superficial analysis as a radio-resistant spore in bacteriology. The whole phenomenon, however, of the temporary resistance of an individual cancer cell to the radiations as explained above is an entirely different condition and must be treated accordingly.

No matter how intensive the radiation, it is just as incapable of destroying in every patient all the cancer cells of the treated region as radical surgery is of curing 100 per cent of the operated cases. Therefore the correct technique consists in repeated applications of a correct dose at stated intervals. The insertion of buried emanation tubes should usually be done only once in the same region; but it must be followed by repeated external applications in the surrounding areas.

The following case illustrates clearly the necessity of repeated applications. The patient developed, subsequent to an amputation of the right breast for carcinoma, a nodule of recurrence in the infraclavicular region. Several applications of radium were given. The nodule at first diminished somewhat in size and then remained stationary. The patient discontinued treatment, and when she was seen several weeks later the nodule appared to have increased in size. The nodule was then excised and examined microscopically. The findings were very instructive. Nearest to the skin there was found a thin layer of active carcinoma tissue, while the rest of the nodule throughout its depth consisted of dense connective tissue and did not contain any cancer cells. The only plausible explanation of the appearance of the specimenis as follows: Radium destroyed all the cancer tissue and left behind only a few scattered viable cancer cells in the vicinity. These cells formed a new tumor on the top of the old nodule when the treatment was discontinued. Were the whole layer of active cancer tissue a part of the original nodule then it would

FIG. 17. MICROPHOTOGRAPH. Low power. The darkest area on the surface shows new carcinoma tissue.

have been the first to be influenced by radium, since the latter produced a perfect effect on the whole depth of the nodule This case thus proves conclusively that scattered viable cells may remain uninjured in the path of the rays, even at the surface of the

tumor where the action of the rays was most intense. Hence the necessity of repeated radiations is apparent. Figures 16 and 17 show a gross photograph and a low power microphotograph of the nodule.

Besides the recurrences at the periphery of or at a short distance from the region of the primary tumor the most important cause for the failure of all methods of cancer therapy is the formation of metastases in distant regions of the organism. In the early stages of the disease, these metastatic nodules may be too small to be detected, but they increase in size and virulence while the primary tumor is being treated. The only method at our command to lessen the frequency of these two types of recurrences is to ray prophylactically the regions in which the formation of recurrent or metastatic tumors is probable, and this is in the estimation of the writer the true function of *x*-ray therapy in cancer. For the destruction of a discrete circumscribed cancer nodule of a fair size, the action of radium applied by the aid of modern technique and in the large quantities which most of the operators control to-day, is by far superior to the *x*-rays. On the other hand the *x*-rays should be used when a great deal of ground has to be covered, but where all the nodules are minute or even microscopical. This is the aim of the so-called prophylactic *x*-ray treatment of the chest or of parts of the skeleton. All these areas frequently contain disseminated microscopical groups of cancer cells, though there is no clinical evidence of discrete metastases.

CONCLUSION

To a casual observer it may appear that the practical therapeutic results obtained by radium in cancer should not warrant the enthusiasm of the radiumtherapeutist. But a closer student in the domain of radiumtherapy cannot fail to appreciate the fact that radium is the most powerful agent in the whole therapeutic armamentarium of medicine, and that the selective action of the element, when the quantity and quality are correctly adjusted, presents a most remarkable phenomenon. Moreover not all of the failures by far must be ascribed to the inefficiency of the agent. The percentage of cases suitable for radiumtherapy is as small as the number of cases suitable for radical surgery.

Even if radiumtherapy should not have accomplished anything else, it is of great value because it is gradually dissipating the feeling both within the profession and the laity, that a diagnosis of cancer means a death warrant. The association between radium and cancer is also becoming more generally realized. As a result the radiumtherapeutist is being called upon with increased frequency to decide on matters which are purely in the domain of cancer research. It is imperative therefore that every radium worker should become a student of the whole domain of cancer research—biology, pathology, clinical diagnosis, surgical or combined therapy. Each radium establishment which controls large quantities of element, should become a center for cancer research. Both greater success in the results of radiumtherapy in cancer and progress in the knowledge of the whole cancer problem will follow this course of action.

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A STEREOSCOPIC TUBE STAND PARTICULARLY ADAPTED FOR THE EXAMINATION OF THE SKULL

By PAUL C. HODGES, M.D.

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THE apparatus here illustrated was designed with the idea of simplifying the examination of the mastoids, sinuses and jaws—including the lower molar teeth—by the stereoscopic method. Its chief difference from existing apparatus lies in the fact that when the angle of the central ray is once chosen it remains fixed during the exposure of both plates, except for a shift of five degrees each way from the center. This shift does not affect the centering of the ray. A practical modification of the well-known weighted bandage for immobilizing the head during the exposure is also described.

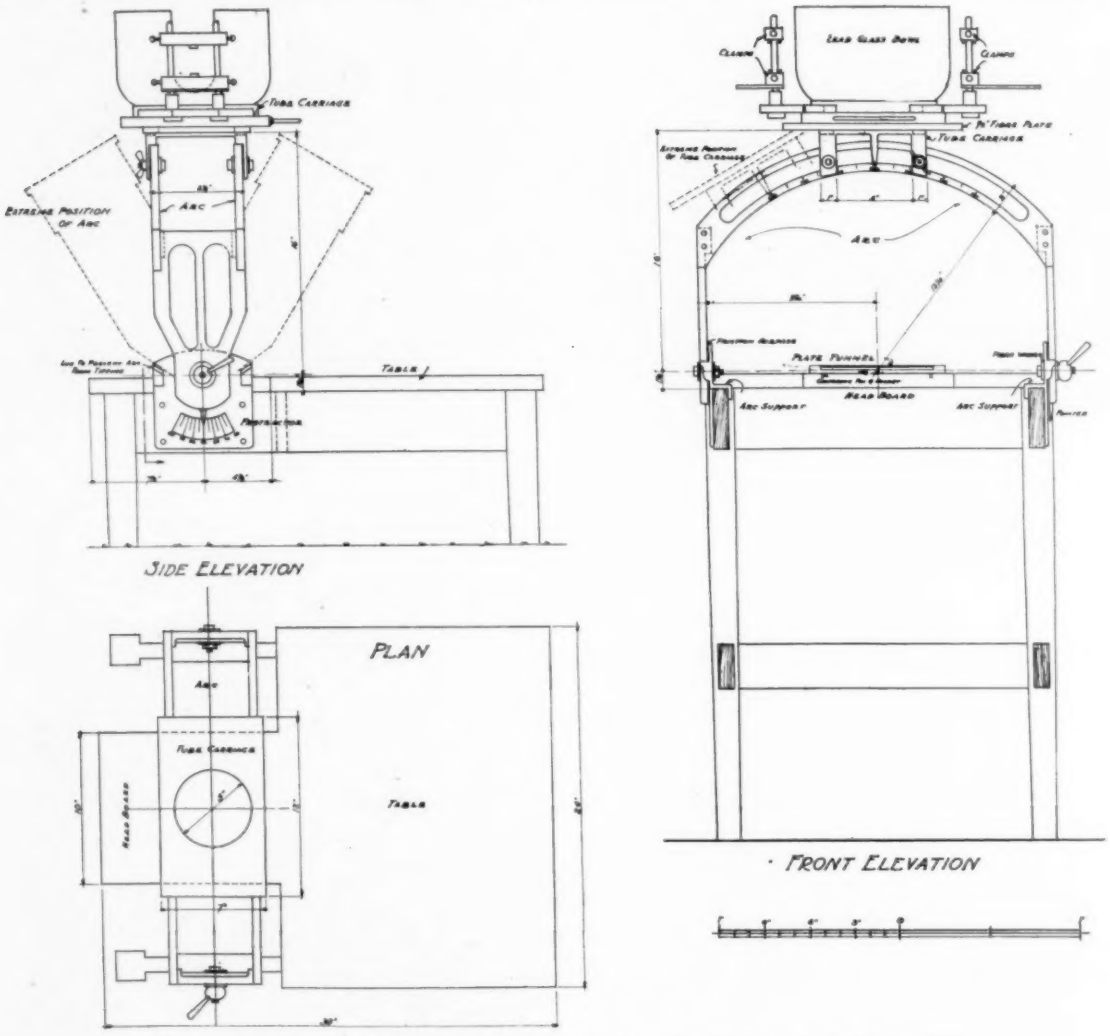

FIG. 1. DIAGRAM OF TUBE STAND SHOWING TOP, FRONT AND SIDE ELEVATIONS.

During six months of constant use the machine has performed satisfactorily in the

writer's laboratory, apparently supplying a solution to the problem of consistent stereoscopic skull technique in busy laboratories, where the exposures must be made by technical assistants.

FIG. 2. SHOWING THE EXTREMES OF MOTION OF THE ARC AND OF THE TUBE CARRIAGE. Also the Head Strap and the Adapter for 5 x 7 Films.

FIG. 3. SHOWING THE STEREOSCOPIC TUBE STAND ASSEMBLED.

The base consists of a small wooden table made the same height as the exposing table. The table top is cut out in the manner illustrated (Fig. 1), so that a central tongue remains as a support for the aluminum plate tunnel, with notches on either side for the passage of the immobilizing bandage. Bolted to either side rail are aluminum supports, and pivoted from these supports rises an aluminum arc which serves as the bed for a carriage mounting the tube clamps, lead glass bowl and tubular diaphragm. By moving the arc forward and backward and moving the tube carriage to the right or left the focal spot of the tube can be made to occupy any desired point on the upper surface of an imaginary sphere, the center of which lies at the center of the *x*-ray plate. It is impossible, therefore, to make the central ray fall anywhere except on the center of the plate. A protractor is fastened to the right hand arc support, and a pointer on the arc indicates the number of degrees to which the arc

FIG. 4. SETTING THE STAND FOR THE FIRST EXPOSURE OF A PAIR OF MASTOID PLATES.

is tilted away from the transverse plans in either direction. The arc itself is also marked in degrees and the tube carriage carries a pointer to show the degrees of displacement to the right or left of the longitudinal plane.

shifted five degrees each way from the selected angle on the arc.

The head strap was devised to overcome the nuisance of improvising a bandage for each new case. It consists of two-ply white

FIG. 5. THE POSITION FOR FRONTAL SINUSES.

FIG. 6. POSITION FOR LOWER LEFT MOLARS WITH TUBE ANGLED 70 DEGREES FROM BEHIND AND DISPLACED 10 DEGREES TO THE LEFT.

With both pointers at zero the central ray is perpendicular to the plate, and when its direction is altered in either or both planes, the foot point still lies at the center of the plate. To determine, therefore, the point on the skull from which the rays are going to emerge, one has merely to select that point in contact with the cross mark in the center of the aluminum plate tunnel. Or conversely, when it is desired to cause the central ray to pass through the skull in a particular direction in relation to—say—the saggital plane, and emerge at a given point, say the external auditory meatus, one has merely to place the head with the saggital plane parallel to the plate, and with the external auditory meatus directly over the center of the plate, and then adjust the tube carriage to the desired angles. For stereoscopic effects the tube is now

cotton cloth 4½ feet long and 4½ inches wide at the broad end. The perforations at either end are reinforced by tape or metal so that they will not be torn by the hooks that fasten them to the sandbags. The slit for receiving the small end of the strap is overcast to strengthen it. Such straps are provided in quantity so that they can be laundered fresh for each patient.

A sheet metal tray is provided to adapt 5 by 7 film holders to the 8 by 10 tunnel, this size of film being quite satisfactory for examination of the mastoid region and the lower molar teeth. 8 by 10 films are used for examination of the sinuses.

The photographs illustrate the technique for mastoids, sinuses and teeth.

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SECOND ANNUAL MEETING EASTERN SECTION

The Second Annual Meeting of the Eastern Section of The American Roentgen Ray Society will be held in Atlantic City at Haddon Hall-Chalfonte, on Friday evening and Saturday, January 28, 29, 1921. Make hotel reservations early.

Communications regarding the program should be addressed to Dr. David R. Bowen, 82 West LaCrosse Ave., Lansdowne, Pa.

In all other matters concerning this meeting, address Dr. Joseph M. Steiner, 103 Park Ave., New York City.

THE LEONARD PRIZE FOR RESEARCH

THE AMERICAN ROENTGEN RAY SOCIETY will award $1000.00 to the author of the best piece of original research in the field of the *x*-ray, radium or radio-activity. The competition is open to anyone living in the United States or its possessions, in Canada, Mexico, Central or South America, Cuba or other islands of the Western Hemisphere. The research matter must be submitted in literary form in the English language not later than July 1st, 1921, and must never have been published. Each paper must be signed by motto and accompanied by a sealed envelope containing motto and name, so that the identity of the author may be disclosed after the award has been made. In case a demonstration of an invention or method is necessary, the identity of the author may have to be known before the award is decided.

The field of research includes discovery, invention, improvement of method, or investigations to prove or disprove any theory or problem, whether old or new, which has a direct bearing upon the use of *x*-rays, radium or other radio-active substances.

This competition is not open to any research involving a patent or copyright, and the submission of any research work for this prize carries with it the understanding that the subject matter will remain open to free use for the general good.

The committee reserves the right to withhold the award if in its judgment no piece of research offered possesses sufficient merit. It also reserves the right to divide the award if two papers are judged to be of equal merit. A certificate of honorable mention will be given to the author of meritorious research which has been submitted but which has not received the prize.

Papers, records or material are received in this competition only with the understanding and agreement that any work receiving award or honorable mention may be published in The American Journal of Roentgenology at the discretion of the research committee. All expenses of publication will be borne by the Journal. Papers not published will be returned to the authors.

The piece of original research receiving award must be presented before The American Roentgen Ray Society at its next Annual Meeting, September, 1921.

This prize is offered in an altruistic spirit for the promotion of useful research, with the approval of the National Research Council. It commemorates the name of a martyred member of The American Roentgen Ray Society, Dr. Charles Lester Leonard, who paid the supreme penalty for his pioneer research in the field of the *x*-ray.

Communications may be opened with any member of the following committee:

A. W. Crane, *Chairman*
420 South Rose St., Kalamazoo, Mich.
P. M. Hickey, M.D.
32 Adams Ave. W., Detroit, Mich.
Henry K. Pancoast, M.D.
University Hospital, Philadelphia, Pa.

DR. MILLS'S ADDRESS

Dr. Mills's memorable address at the Minneapolis meeting presented ideals of roentgenologic practice that are not beyond our reach. To review the history of the case, the physical examination, the laboratory findings, and to correlate with them the roentgenological interpretations, is to exercise the true art of diagnosis. The roentgenologist then qualifies as a consultant on an equal footing with the internist or the surgeon. It is to this end that he should have a medical degree and a working experience in hospital or general practice. He should feel the pride and support of professional traditions and cultivate the same sensitive ethical sense as the men with whom he would consult. His status is then fixed beyond the competition of technicians and irregulars.

Under the spell of Dr. Mills's words the practice of roentgenology takes on greatly increased interest. The problems widen to include nearly the entire domain of medical and surgical diagnosis. It again becomes necessary to read medical journals, to study the latest volumes on practice, and to attend medical societies. The narrowing effect of a specialty is lost because the specialty of roentgenology thus conceived leads into a professional life of unusual breadth and perspective.

No other great province of medical science is so new and so rich in promise as roentgenology. Its fruits are already found in nearly every other department of practice. It offers unmeasured tracts of research to the investigator. It touches chemistry, physics, the activities of the electron, and the constitution of matter as intimately as it does the diagnosis and treatment of disease.

To have clinical experience is more than desirable, but to be a pathologist is not less than a necessity to the best type of roentgenologist. *X*-ray interpretation is a statement of screen and plate findings in terms of pathology. The *x*-ray furnishes to the diagnostician an exquisite analysis of densities, but nothing else. The evidence is presented to the sense of vision only. From such data we have to define the extent of disease and deduce its nature as far as possible. Bone lesions offer the clearest examples of pathological interpretations. But in the wider field of internal disease we must beware lest we go beyond our premises and draw conclusions warranted only by a digest of the entire case.

The import of Dr. Mills's contentions applies with undiminished force to the practice of *x*-ray therapeutics. The skilled physician is needed to prescribe this unfelt and unseen agent, no less than to prescribe tablets and tinctures. The expansion of *x*-ray treatment will in the future be seen to mark an era in

medicine. It comes at a time when the decay of faith in drugs has left the therapeutic field to the dominant sway of the surgeon. There is therefore a province to be reconquered by the most powerful and least tangible agent that has ever been used to mitigate the sufferings from disease.

The *x*-rays and radium are indissolubly associated both in therapeutics and in nature. They bear something of the same relation that the electro-magnet bears to magnetic ore. One is the result of the electric current, the other a product of earth. But their essential activity is identical. Everything about radio-activity stimulates speculation. The action of radiations on the living cell forms or will form a basal chapter in therapeutics. Some sort of radiant energy seems to be the basis of the activity of most medicinal substances. The presence of end-products of radium, widely scattered through the earth's crust, suggests that radium was once in astonishing abundance on this planet. We are led to wonder if what Bovee has called the imponderable environment of radiations was not the most powerful influence in the evolution of primordial protoplasm. What then would be the rationale of the restoration of the evolutionary environment of living matter?

Speculation of a highly tenuous nature thus goes hand in hand with the intensely practical matter of curing disease. Research in pure science, seemingly at an infinite distance from the practical affairs of life, have time and again proven in the end to be of inestimable utility. The history of scientific research is a fairy tale of the transmutation of speculations and experiments into power and production. Faraday's absorption in twirling a metal disc between the ends of a magnet was doubtless unintelligible to the hard-headed business man of his day; yet the business man of our day runs factories and locomotives and illuminates cities as the consequence of this first experimental plaything. The *x*-ray was conceived in the theories of Brookes concerning the fourth state of matter. His experiments with the transmission of electricity through vacuum tubes was the purest example of pure science undefiled by any apparent utilitarian possibility. Yet few discoveries in the history of civilization can equal the practical consequences of these experiments. Research therefore should be encouraged and sustained by our society as the best expression of our scientific faith and our best contribution to future generations.

We need other addresses from Dr. Mills to uphold our ideals and make us think. Our opportunities are always greater than our achievements. But let us hold high the torch. Whether our roentgenologist is a diagnostician or a therapist we would have him be an experienced clinician, an able pathologist and withal a man of the broadest scientific culture.

A. W. Crane.

AN EPIGRAM

"I AM A PHYSICIAN PRACTICING SURGERY."
SIR BERKELEY MOYNIHAN.
(Lecture at the Academy of Medicine, N. Y., October 21, 1920.)

A great phrase uttered by a great surgeon! How well it would be if every roentgenologist reminded himself daily that:

"I AM A PHYSICIAN PRACTICING ROENTGENOLOGY."

AMERICAN ASSOCIATION OF MILITARY ROENTGENOLOGISTS

At the Annual Meeting of The American Roentgen Ray Society at Minneapolis an association of roentgenologists, called the American Association of Military Roentgenologists, was organized with the following officers elected:

President
Col. A. C. Christie
Vice-President
Henry K. Pancoast, M.D.
Secretary
F. F. Borzell, M.D.

Information concerning the organization

will gladly be given upon application to the Secretary. Those eligible to membership are officers of the Medical Corps and Sanitary Corps who were actively engaged in the Roentgen Ray Service during the Great War, either at home or abroad.

F. F. BORZELL, *Secretary.*
1119 Harrison St., Philadelphia.

NOTICE

To the Members of the
AMERICAN ROENTGEN RAY SOCIETY,

The Committee on Revision of the Constitution recently appointed will hold its first meeting at the Mid-Winter Session of the Eastern Section at Atlantic City. It is very desirable that those members of the Society who desire to present amendments to the Constitution should send them to the Chairman of the Committee before the first Committee meeting. This would allow the Committee sufficient time to consider definitely and coordinate the various suggestions.

At the Annual Meeting, this Committee was authorized to publish its recommendations in the June number of the JOURNAL.

This will allow sufficient time to permit all the members to consider the proposed amendments very carefully.

(Signed) A. L. GRAY, *Chairman.*
E. C. SAMUELS,
P. M. HICKEY.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

TRANSLATIONS & ABSTRACTS

PHEMISTER, D. B. The Recognition of Dead Bone Based on Pathological and *X*-Ray Studies. *(Annals of Surgery,* Oct., 1920. Vol. lxxii, No. 4, pp. 466–485. 17 Figs.).

When bone dies rapidly and in appreciable quantity from infection in osteomyelitis, compound fractures, tuberculosis and rarely in lues, it is at first indistinguishable either by gross or roentgenologic appearance from the adjacent living portions. Only after the occurrence of further changes in the living and the dead bone can its extent be determined. A detailed knowledge of these changes is essential for diagnosis and for planning suitable and properly timed operations.

The points by which we distinguish between dead and living bone are density, demarcation, and contour. These are best determined by means of the *x*-rays and can be expressed as follows: The density of dead bone is greater than that of an equal volume of surrounding living bone. It retains its original compact texture. Living old bone has its density evenly reduced by atrophy and is occasionally streaked from dilated longitudinal cannular markings. Newly formed bone is of low density and spongy in texture. However, there are numerous variations from these general statements. Dead bone when extensively eroded has its shadow density reduced, which may be equal to or below that of the living bone, but is distinguishable from the latter by its blotchy uneven character. Secondary sequestra usually show no variation in density from the adjacent living bone. The line of demarcation between dead and living portions is usually sufficiently wide and clean cut to be of great value in diagnosis, but any oblique or tortuous portions may be indistinguishable. Notches or unevenly streaked lines may indicate incomplete separation of the dead piece.

The outline of the sequestrum is of great diagnostic value. Its surface is smooth, sharp, straight where unattacked, but irregular and jagged where erosion has occurred. Sharp spicules, especially about the ends, are frequently to be made out. Preservation of the smooth curved cortical rim in sequestra bordering on an articular surface and of clean-cut fracture lines late in infected fractures are points of value. The compact texture of dead bone gives its outlines a sharpness that the less dense and frequently growing living surfaces do not possess. Evidence of irregular destruction of spongy bone at the ends of the shaft in osteomyelitis is a sign that dead portions are present though their outline cannot be determined.

There are many difficulties in distinguishing dead bone in the *x*-ray, the greatest of which results from overlapping of shadows of necrotic and living portions which obscures the details of each. This can be obviated by marking plates at different angles.

The presence of dead bone can nearly always be diagnosed, but frequently the exact number of pieces cannot be determined, especially when they are small. At operation in osteomyelitis and infected fractures we often find twice as many sequestra as were suspected from the *x*-rays.

Wounds containing small sequestra may heal and remain closed indefinitely, but eventually lighting up of the infection may occur. Ununited fractures and defects requiring bone transplantation should be scrutinized; if tiny healed-in sequestra be found, they should be removed and the transplantation postponed until the wound has sufficiently long healed.

The difference in density between dead and living bone in septic necrosis suggested the possibility of a similar occurrence in aseptic necrosis, such as takes place in uninfected bone transplants. Histological studies have shown that nearly all of the transplanted compact bone undergoes aseptic necrosis which, after reestablishment of the circulation, is gradually replaced by new bone formed from the surviving unossified osteogenetic elements of transplants in case the latter takes, or growing in from the surrounding bone where it does not take.

Experiments on dogs have shown that atrophy occurs more rapidly in the adjacent living bone than in the transplant, because time is required for the reestablishment of circulation and the beginning of absorption in it with

replacement of the dead cortex by new and less dense bone. A section of ulnar shaft two-thirds to one and one-half inches long, excised and reimplanted, is denser and casts a heavier shadow from the fourth to the tenth week than the adjacent atrophied fragment. After this time the density of the transplant gradually approaches that of the fragments.

A difference in density gradually develops between the infected and uninfected portions of a human transplant. This is illustrated by the following case: A tibial inlay graft was inserted for ununited gunshot fracture of the lower end of the humerus. Mild infection occurred with fistula formation at the seat of the fracture. Two centimeters of the lower end of the graft underwent septic necrosis and separated as a sequestrum. It casts a heavier shadow than the rest of the graft which took and has undergone considerable transformation.

MEDICO-LEGAL. Liability of Roentgenologist. (Gross v. Robinson [Mo.], 218 S. W. R. 924.) (*J. Am. M. Assn.*, Vol. lxxv, No. 16, p. 1087.)

The Kansas City (Mo.) Court of Appeals says that, according to his allegations, the plaintiff, having had one of his ribs fractured, applied to the defendant to have a roentgenogram of it made. The defendant exposed him to the roentgenographic rays twelve or fifteen times more or less within two weeks, or for approximately 375 seconds, at a target skin distance of about 10 inches, using about 30 milliamperes of current, and with a spark gap of not less than 2½ inches, causing severe and lasting injuries. The trial resulted in a verdict in the plaintiff's favor for $10,000 damages, of which $2,500 was remitted, and a judgment for $7,500 was rendered, which is here affirmed.

Complaint was made that the trial court allowed the plaintiff to introduce evidence tending to show a machine which lacked certain appliances, when such condition was not pleaded. The avowed object in such testimony was only for the purpose of proving the negligence charged; that is to say, if a machine was not equipped with a filter, it was negligence not to use it. There was no pretense that the absence of the filter was, itself, negligence. But a filter being absent, it was negligence to make a certain character of exposures for a certain time, without the protection of a filter. Such evidence was necessary for framing an intelligible hypothetic question to an expert. Furthermore, evidence tending to show that the sore made by the burn would probably become malignant was given and justified under the plaintiff's petition.

A salesman for the company that had sold the machine to the defendant was at the latter's office and, after the defendant had failed with one or more exposures, was asked to try whether he could take one, which he attempted to do, but failed. It further appeared that, after the defendant had made several failures, he telephoned, in the plaintiff's presence, to another physician, and asked him to come and take a picture. The physician came, made the attempt, but got no picture. The defendant contended that he was not liable for the acts of either of these uersons, and that as their attempts to secure a picture may have been the exposures that caused, or substantially increased, the plaintiff's injury, a case was not made against the defendant. With regard to the responsibility of the defendant for the acts of the other physician, it seems that the relation of master and servant, or of principal and agent, does not exist between two physicians where one has been sent to treat the patient of the other with the consent of the patient. In such instance the rule of respondeat superior or let the master answer, does not apply. From this legal standpoint, should the defendant be held, as a matter of law, not liable, as regards the other physician, on account of the part the latter took in the case? The court thinks that it should not so rule. The defendant had already caused two or more exposures, when he had the other physician intervene and in his presence take another with the same machine, the defendant then resuming the same treatment with the same machine. The defendant's continuance of the exposure with knowledge of what the other physician had done tended to show an adoption of the latter's effort. Keeping in mind that it was the number of exposures, within a given time, made as these were, that may have been the cause of the plaintiff's injury, especially when considered with the defective machine and with the defendant's

knowledge of these things and of his presence when the other physician acted, it would seem to be unrighteous and unreasonable to absolve the defendant from liability for the other physician's negligence as a matter of law. It was a question for the jury. As to the salesman's part, the court finds less excuse for the defendant's contention, for the salesman was not a physician and made no pretense to the experience and skill of an expert in the medical profession.

The defendant claimed that he warned the plaintiff of the danger in more than two or three exposures in a given time, and that if the plaintiff insisted on them it would be at his risk. But while the plaintiff may have assented to more than the two or three exposures, yet, of course, he did not assent to a careless exposure, with a machine that was out of order. While there was evidence tending to show that he was warned against more than three exposures and assented to a greater number, he did not consent to negligent conduct in the manner of taking the exposures, or of the defects in the machine used by the defendant.

JUDD, E. S. The Results of Surgical Treatment of Exophthalmic Goiter. (*New York State Journal of Medicine*, September, 1920. Vol. xx, No. 9.)

In discussing the causation of the disease the author contends that there is always a hyperplasia of the thyroid; and that while it is not supposed to be the only tissue change, no case of exophthalmic goiter exists in which there is not this very certain and positive change. He suggests that it had best be grounded with toxemias, and that it is under the control of cellular changes that occur in the thyroid. When a part of the thyroid is removed the symptoms subside, and if they return they are always associated with an enlargement of the part of the gland which was not removed. In discussing treatment he contends that the disease occurs in attacks. If the patient is under a downward wave of the attack, that is, if the nervousness is increasing and the strength and weight decreasing, no surgery should be undertaken. He thinks that this has a very material bearing upon the recovery of the patient; but if they are carried over this climax by rest, increased elimination, etc., and perhaps ligation of the thyroid vessels, the acute stage may be passed and the patient prepared for surgical relief later.

The result of these palliative measures is often striking, especially following ligation, and there is a tendency to consider the patient cured because he appears to be much improved. It is always best to advise a thyroidectomy as soon as recovery is sufficient to make it safe, since they will be much better after the gland is removed, and the danger of relapse will be very materially reduced.

Until recently, we depended entirely on the clinical picture and physical findings by which to estimate the degree of toxicity in the cases of hyperthyroidism, but in the past few years it has been shown that the toxicity may be measured accurately by the changes produced in the basal metabolic rate. The basal metabolic rate is always increased in cases of hyperthyroidism, and decreased in cases of hypothyroidism. While some unknown factors may enter into the problem of hyperthyroidism the changes in the metabolic rate are characteristic and give an accurate method for the determination and estimation of the degree by thyroid toxicity.

Means and Aud, in a recent article, have shown in detail the influence of *x*-ray treatment. Their results were estimated largely by metabolic studies, and were compared with a series of cases in which surgical treatment had been given. They concluded that results from *x*-ray treatment are more satisfactory since there were no fatal cases, and that ultimately, especially as far as the metabolic rate was concerned, the results were about the same as in cases in which operation was done. The report is interesting and seems to show that the *x*-ray has some influence on thyroid activity.

The mortality following surgical treatment is due most often to increased hyperthyroid which occurs in spite of treatment. Dr. Judd reviews the conditions of 100 consecutive patients operated on in 1914. There was a mortality of 2 per cent. of this 66 per cent are free from disease after the operation, and 13.5 per cent show marked improvement, while 5.5 per cent show slight improvement. Eleven of the one hundred patients died after leaving the clinic. The series studied in 1909 show only 44 per cent cured. The difference between the number of cures in 1909 and 1914 is due to difference in technique.

BECK, HARVEY G., and EVANS, JOHN. Comparative Study of Gastric Motility as Determined by the Ordinary Test Meal and Six Hour Barium Retention. (*J. Am. M. Assn.*, Vol. 73, No. 23, December 6, 1919.)

Our observations indicate that frequently when adhesions involve the pylorus and duodenum, the power of the stomach to empty itself is at first increased and later diminished. The degree of gastric acidity seems to have little or no influence on the amount of gastric contents after a test breakfast or six hour retention. No interpretation should be made on this point without studying the acid curve by the Rehfuss method of fractional gastric analysis. The motor function of the stomach can be determined by the complete removal of a standard test meal with the partial vacuum method. There is no constant relation between the motor function as determined by the test meal method and six hour barium. Six hour barium retention occurs after a motor meal if the stomach contents exceed 200 c.c. in fifty minutes or 150 c.c. in sixty minutes. The comparative results of the two methods are most uniform and constant in duodenal ulcer. Six hour barium retention occurs more frequently in adhesions involving the pyloroduodenal region than in either duodenal or gastric ulcer. There is little evidence to show that the secretory function has any influence on the motor function in pathologic conditions affecting the stomach and duodenum.

SUBBEL. Hydatid Cyst of the Lung Discovered by Radiography. (*Bulletins et Mémoires de la Société de Radiologie Médicale de France*, April, 1920.)

A man, age twenty, came for radiographic examination, with the following clinical findings: Modified respiratory sounds in the left apex; fremitus increased, vocal resonance increased. Patient had lost some weight, and had been spitting blood recently. Fluoroscopic findings were: Diminution of the light reflex in the left apex. Lessened transparency beneath the clavicle. Right light reflex normal, subclavicular region clear. At the level of the second rib in front, and 6 cm. to the right of the midline, was seen a shadow about the size of a two-franc piece, with regular and well defined borders moving with the respiratory movements. From the side, this shadow was seen to be 1½ cm. behind the anterior thoracic wall. Its shape, viewed thus, was circular, density uniform and borders regular. These characteristics suggested hydatid cyst. The patient then gave a history of having been closely associated with a young shepherd dog, which he had commonly carressed. Dogs are commonly the host of the tenia echinococcus. The complement fixation test of Weinberg was positive. Blood examination revealed numbers of Eosinophiles.

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